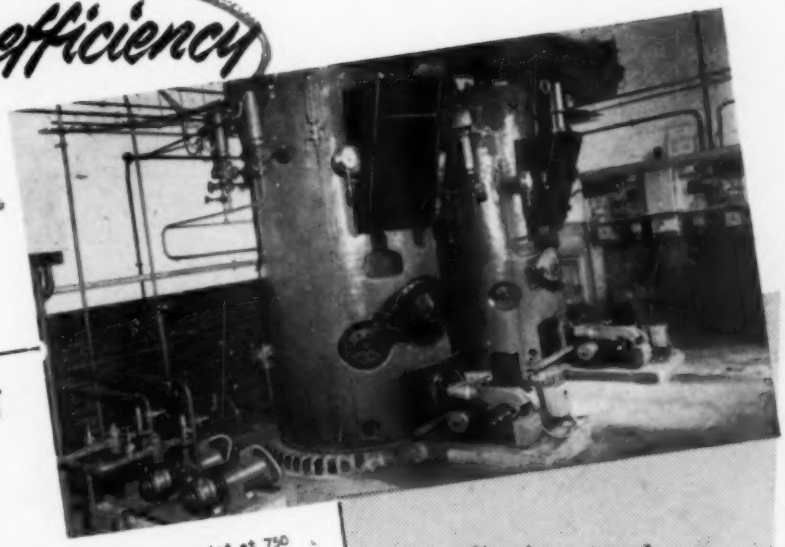
# METALLURGIA

THE BRITISH JOURNAL OF METALS

Vol. 64 No. 385 NOVEMBER, 1961 Monthly: Two Shillings and Sixpence



77% Boiler efficiency -with standard equipment



COMBUSTION TEST REPORT:

Installation at: Emeralda Limited, The United Welsh Mills, Marlborough Road, CARDIFF.

Boilers: 2 Cochran Boilers rated at 750 and 900 lbs. steam/hour.
Burners: 2 Nu-way SBW.1C.R/L burners.
Fuel: B.P. Britoleum. 200 secs.viscosity.

| | No.1 Boiler | No.2 Boiler |
|---|---|---|
| HIGH FLAME | | |
| $CO_2$ content flue gas Furnace: | 15% | 15·2% |
| Boiler Exit: | 12% | 12·5% |
| Flue Gas Temperature Boiler Exit: | 565°F. | 590°F. |
| Shell Smoke Number: | 3. | 4. |
| Boiler Efficiency (Gross C.V.) | 77% | 77% |
| LOW FLAME | | |
| $CO_2$ content flue gas Furnace: | 11·5% | 11.2% |
| Boiler Exit: | 9% | 8·7% |
| Flue Gas Temperature Boiler Exit: | 450°F. | 480°F. |
| Shell Smoke Number: | 3. | 3. |
| Boiler Efficiency (Gross C.V.) | 73·5% | 72% |

NOTE: The drop in $CO_2$ content between furnace and boiler exit indicates leaks causing ingress of air.

Photo by courtesy of Messrs. Emeralda Limited, Marlborough Road, Cardiff.

Heating Installation by Messrs. Union Engineering Co. Ltd., Cardiff.

Test figures kindly supplied by a major Oil Company.

heart of the best heating systems

NU-WAY Oil-firing

NU-WAY HEATING PLANTS LTD. (BOX B853) DROITWICH

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# PROPORTIONING OIL BURNER

◀ *Single lever control*

| | |
|---|---|
| **assures** | **Most accurate control of combustion and temperature.**<br>**Greater fuel economy.**<br>**Better heating uniformity.** |
| **eliminates** | **Guesswork on air-oil ratios.**<br>**Wide variations in temperature.**<br>**Highly trained burner supervision.**<br>**Production variations and losses.**<br>**Waste of fuel.**<br>**Smoke.**<br>**Oil drip or trouble at low fire.** |

SH/SE 6206

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# MORGAN *FAST BULK MELTERS*

## *FOR* GRAVITY *DIECASTING*

The first gravity-diecast overhead-valve aluminium cylinder heads to be produced in this country—for the Rootes Group, Daimler Cars Limited and other leading motor manufacturers —are being made by Aeroplane and Motor Aluminium Castings Limited, Wood Lane, Birmingham.

The high quality metal is melted and treated in a battery of eight MORGAN Basin Tilting Furnaces fitted with SUPREX Crucibles each with a capacity of 500 lbs (225 kg) of Aluminium. The successful production of such large and complicated gravity diecastings is acknowledged to be partly due to unique advantages — FAST BULK MELTING, CONSISTENT METAL QUALITY CONTROL, LOW MELTING LOSS — provided only by a MORGAN Basin Tilter.

*Leaflet FD.33 gives full details.*

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Note these features—

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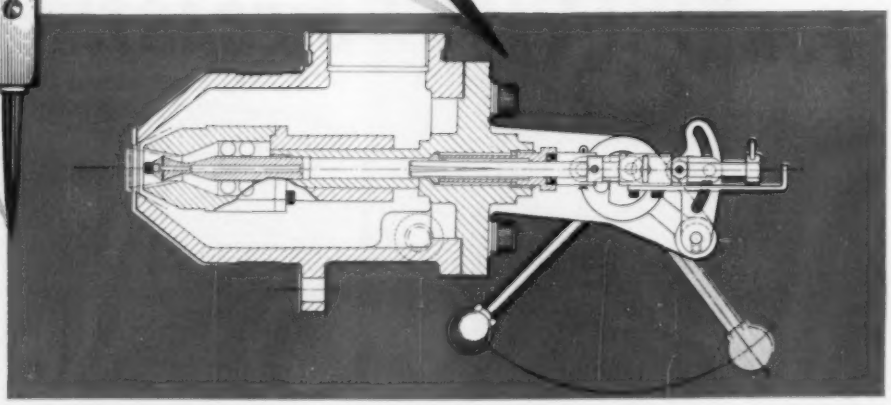
4. Constant velocities of both primary and secondary atomising air, giving uniform flame over a 5-1 turn-down range.



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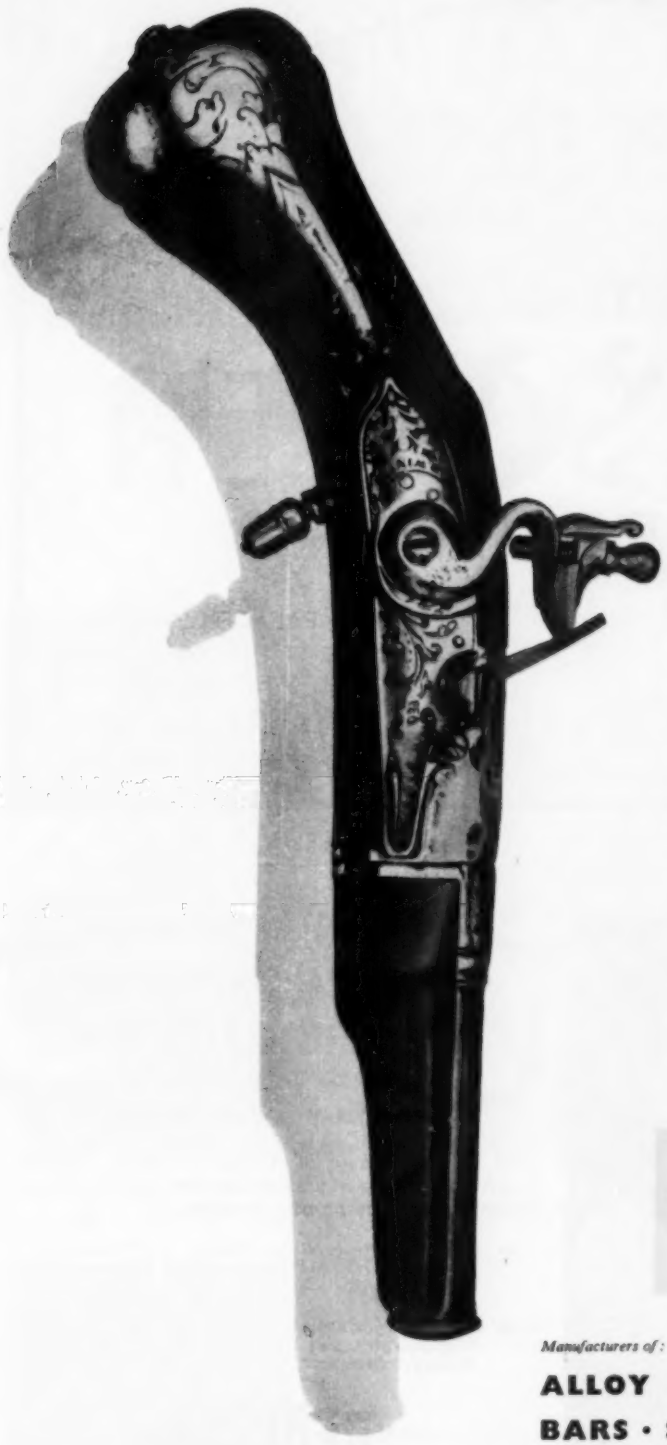
**APPROXIMATE TECHNICAL DATA**

| | |
|---|---|
| **Alumina** | 83% |
| **Refractoriness** — Seger Cone | −38 = 1850°C |
| **Refractoriness under load** 28 lb./in.² (2kg./cm.²) | −5% deformation at 1660°C |
| **After Contraction** — 2 hrs. at :— 1600°C | 0·40% |
| **Apparent Porosity** | 23% |
| **Cold Crushing Strength** | 13,000 lb./in.² (914 kg./cm.²) |

**JOHN G. STEIN & CO. LTD., Bonnybridge, Scotland. Tel: BANKNOCK 255 (4 lines) 361 & 362**



Characteristic of British Craftsmanship is this handsomely worked pistol. Made in the 16th Century from steel and wood it is a fine example of the work of that period and can be seen in the Victoria and Albert Museum.

Britain is proud of her craftsmen ; throughout the years their skilled workmanship has earned a reputation for Britain that is second to none. The historical associations of steel in England chronicled through the ages, show how dependent we have become upon its production. Today its manifold uses in industry and everyday life have become legion—civilisation itself is woven over a framework of iron and steel. Hallamshire high grade Alloy and Carbon steels are an integral part of Britain's traditional good name.

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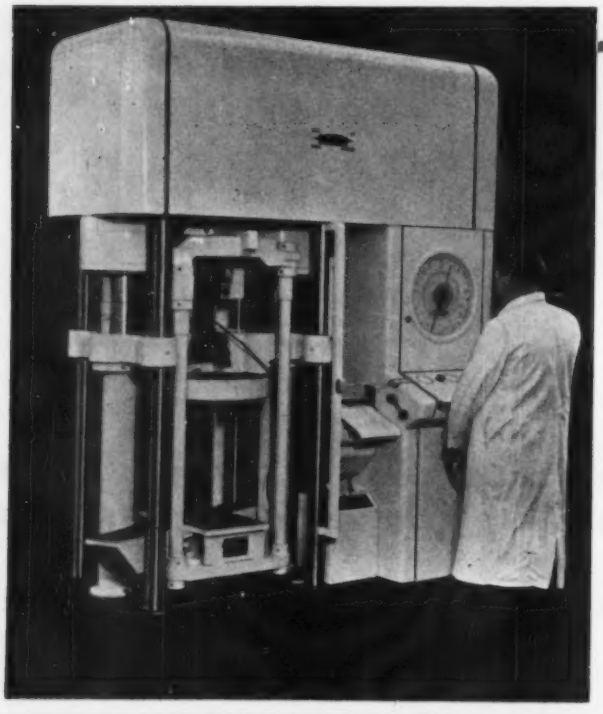

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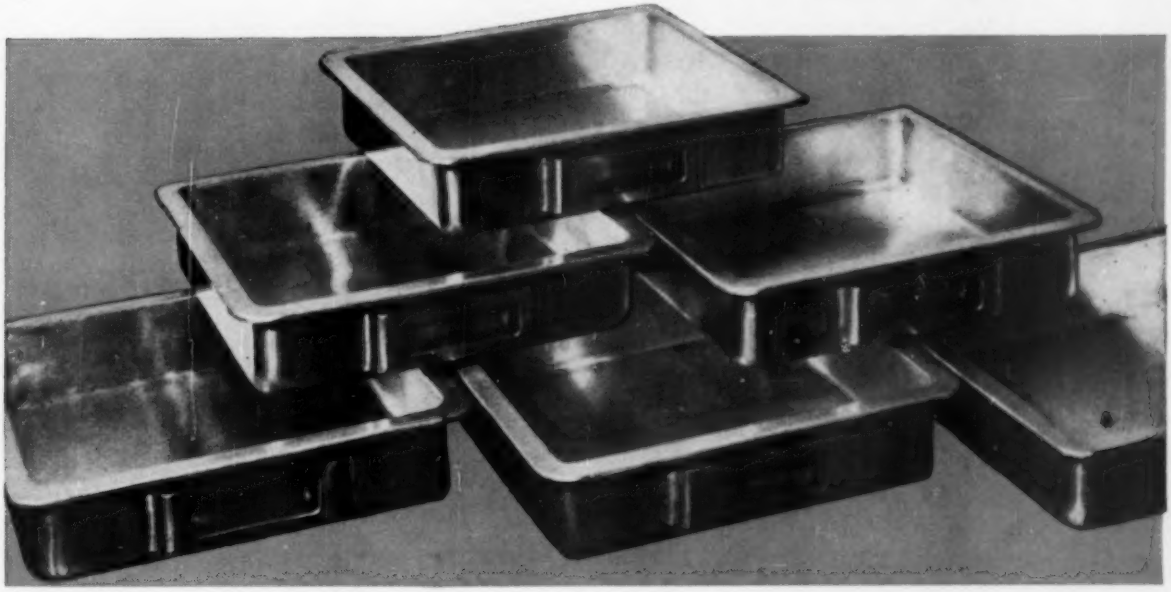

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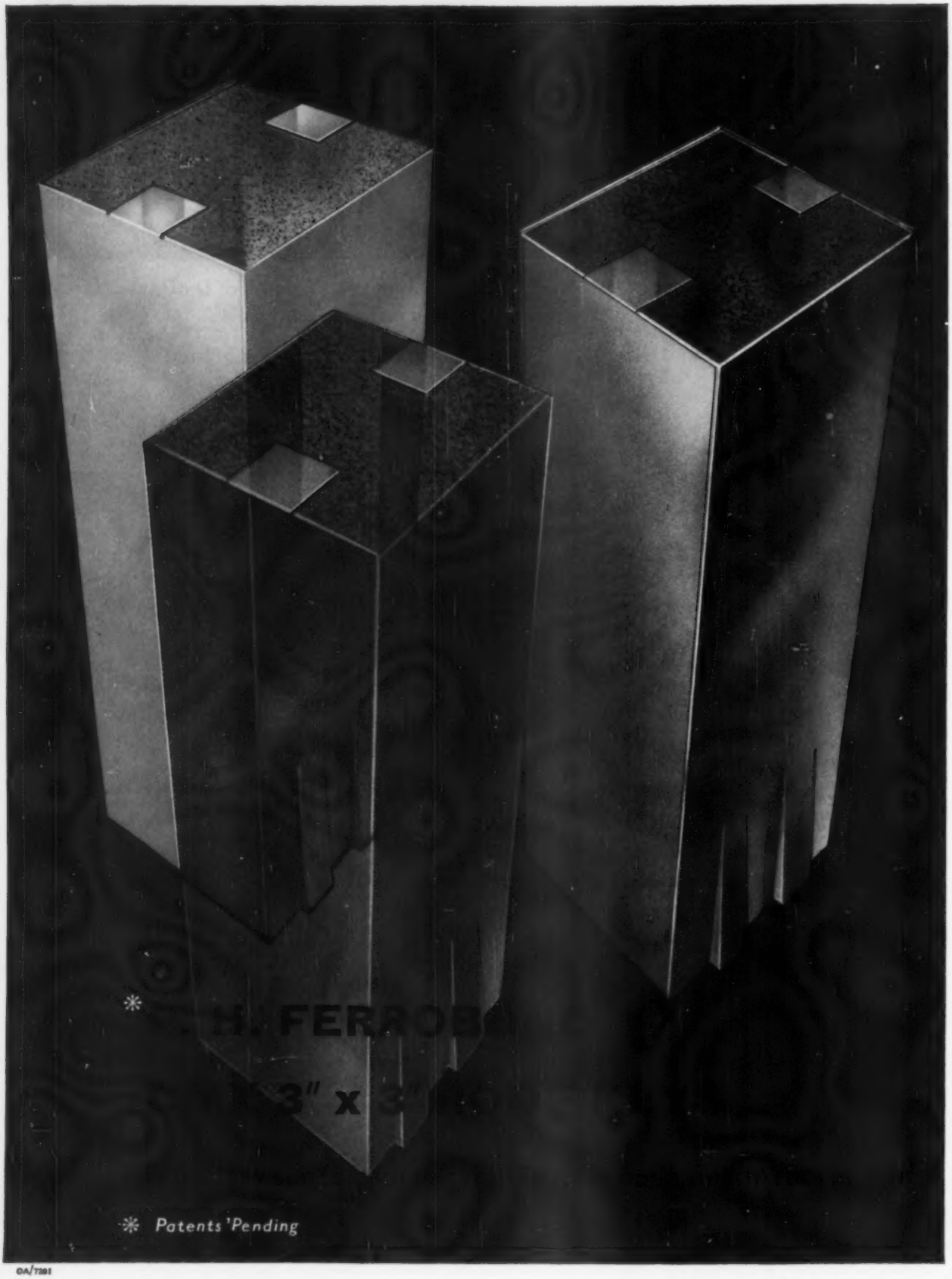


OA/7381

# America, Pickford Holland are now making to-day's most successful basic roof keys

The P.H. Ferrobond CMX 3" x 3" Roof Key is a new, metal-clad, chemically bonded basic open-hearth brick without internal plates, designed by E. J. Lavino & Co. of Philadelphia for maximum service and economy. A series of comparative tests with internally plated 4½" x 3" keys proved Ferrobond to be always equal, and usually superior, in performance. They are light and easy to handle, have built-in hot face expansion, and tabs ensure correct alignment. In addition, saving on material cost by rib and valley construction makes the P.H. Ferrobond beyond doubt today's outstanding value in basic roof brick. Considering a trial? Send drawings of your present roof to Pickford Holland who will redesign to suit Ferrobond bricks, and give you the assistance of a service engineer for installation.

## See how split-roof tests prove OUTSTANDING PERFORMANCE by new FERROBOND ROOF KEYS

| Furnace Capacity | Construction of Roof | Campaign Life | Total Tonnage Produced | Tons/ Hour | % AREA PATCHED | | Oxygen Lances through Roof |
|---|---|---|---|---|---|---|---|
| | | | | | Lavino Ferrobond CMX 3" x 3" Keys | Metal Cased Internally Reinforced 4½" x 3" Keys | |
| 190 Tons | 12" Rib 9" Valley | 284 Heats 112 Days | 54,000 Tons | 20 | 1.8% | 1.6% | 2 |
| 190 Tons | 12" Rib 9" Valley | 250 Heats 75 Days | 47,500 Tons | 26 | 2.2% | 12.6% | 2 |
| 190 Tons | All 12" | 405 Heats 130 Days | 77,000 Tons | 25 | 62% | 67% | 2 |
| 200 Tons | 15" Rib 12" Valley | 486 Heats 196 Days | 100,000 Tons | 21 | 2.8% | 6.6% | NONE |
| 345 Tons | 15" Rib 12" Valley | 453 Heats 170 Days | 157,000 Tons | 38.5 | 10.4% | 19.9% | 2 |
| 400 Tons | 15" Rib 12" Valley | 298 Heats 186 Days | 120,000 Tons | 27 | NIL | NIL | 2 |

*This chart shows comparative performance records in North America of six typical open hearth roofs. In each case the roof was constructed half-and-half of Lavino Ferrobond CMX 3" x 3" Roof Keys and Internally Plated 4½" x 3" Roof Keys. All were of the Fairless type roof construction (hold-up, hold-down). Production rate of tons per hour is based on total production over campaign time, and includes repair times, fettling times, and all lost time whatever the cause.*

P.H. Ferrobond Roof Keys are manufactured under licence from E. J. Lavino & Company, Philadelphia, U.S.A. by

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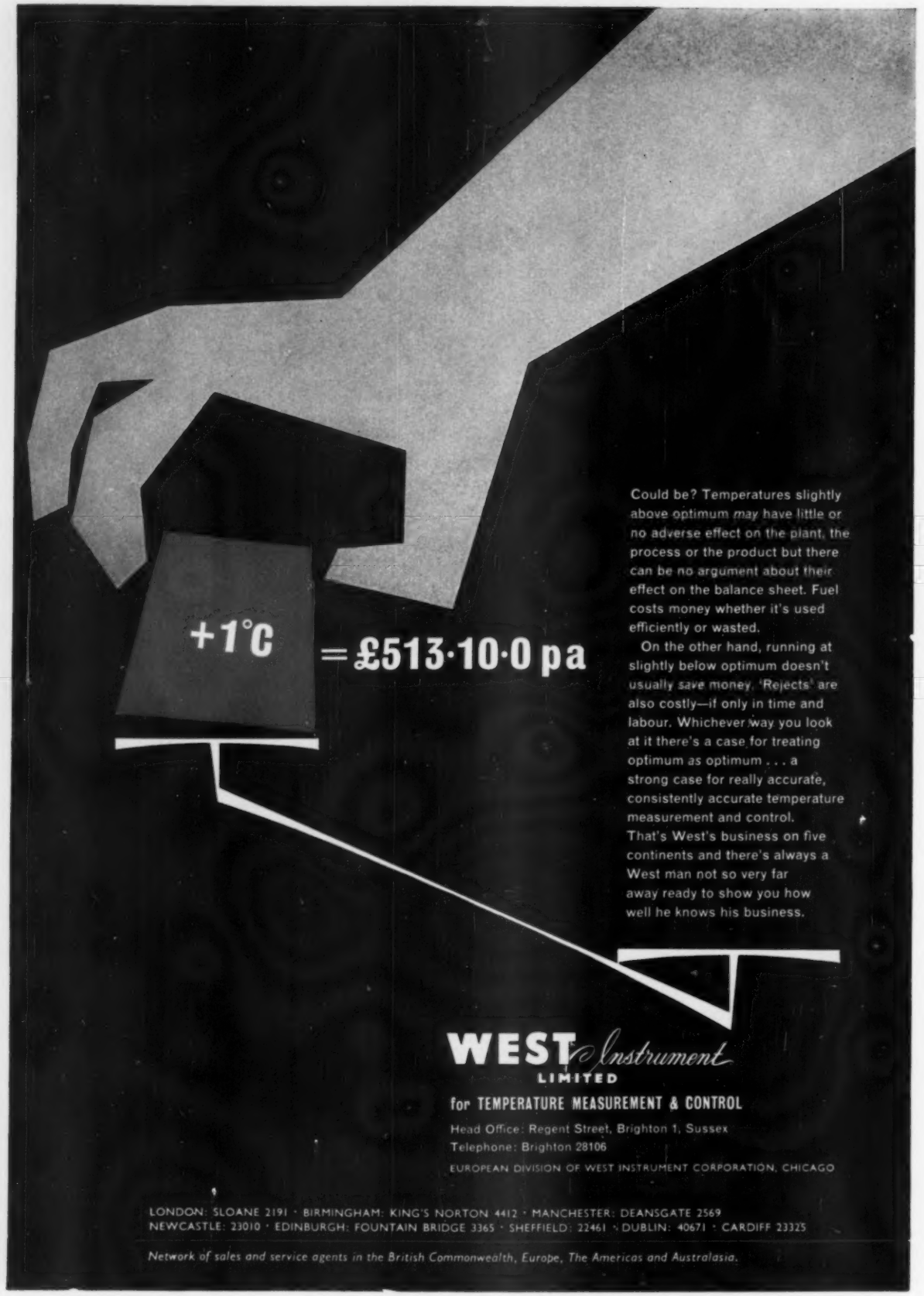


Could be? Temperatures slightly above optimum *may* have little or no adverse effect on the plant, the process or the product but there can be no argument about their effect on the balance sheet. Fuel costs money whether it's used efficiently or wasted.

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# B·D·H

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*T1* and T2** are wires of the nickel-chromium/nickel-aluminium type for use at high temperatures and conform to the British Standard Specification 1827:1952 within the usual tolerances. They also meet the requirements laid down in Air Ministry Specifications 1632 and 1705 covering extensions leads. *Special Advance** wire (60/40 copper-nickel) is for use with copper up to 400°C and with iron up to 900°C. The EMF requirements of these two combinations vary according to individual specifications. Special Advance* wires can be selected in most cases to meet these varying demands within the usual tolerances.

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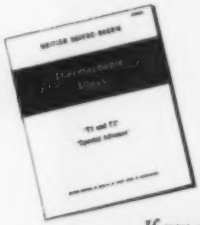

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*If you are interested in thermocouple alloys, then you may like to have a copy of Data Sheet No. 2 for reference.*

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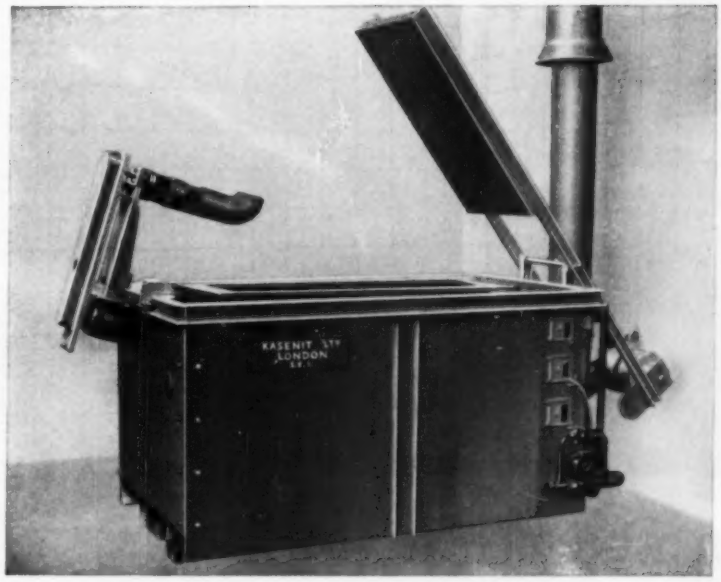


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* *Photograph by courtesy of the Steel Company of Wales Ltd.*

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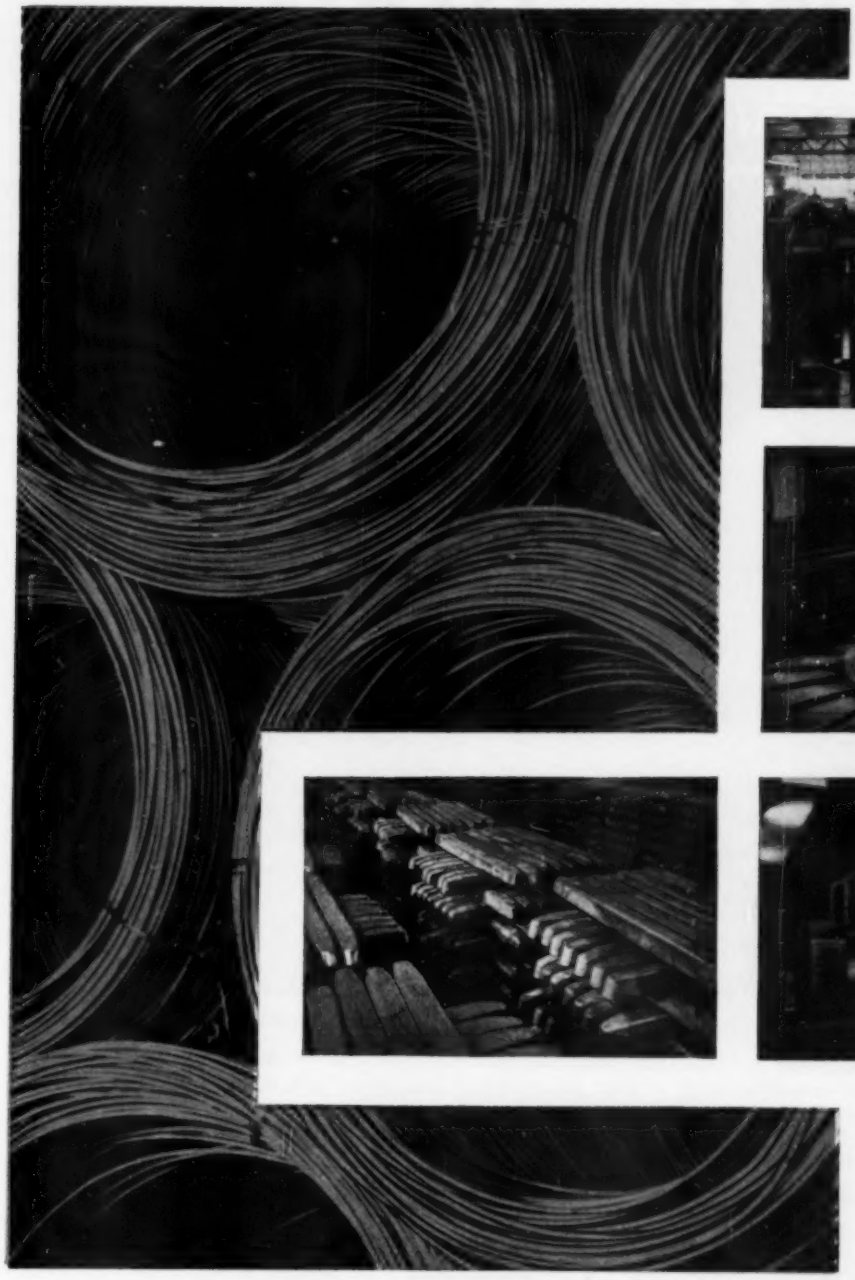

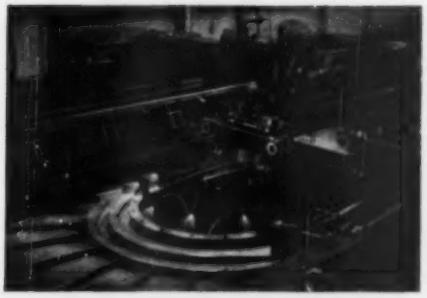

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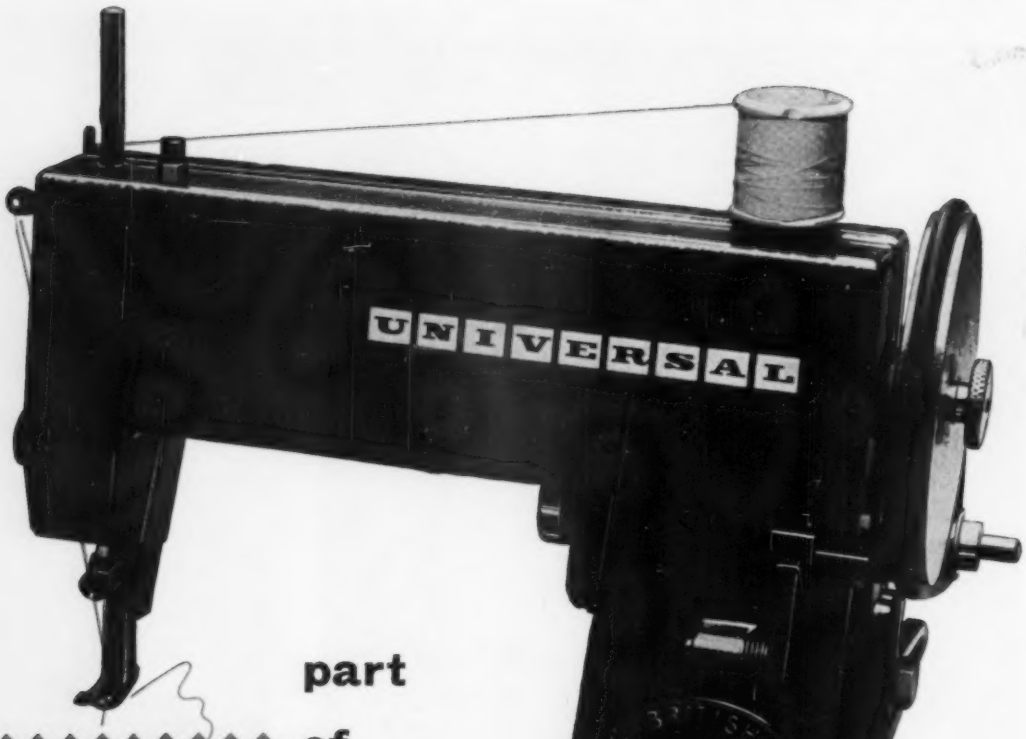


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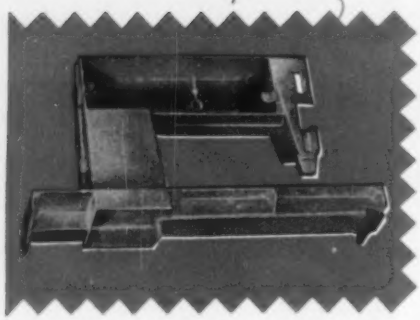

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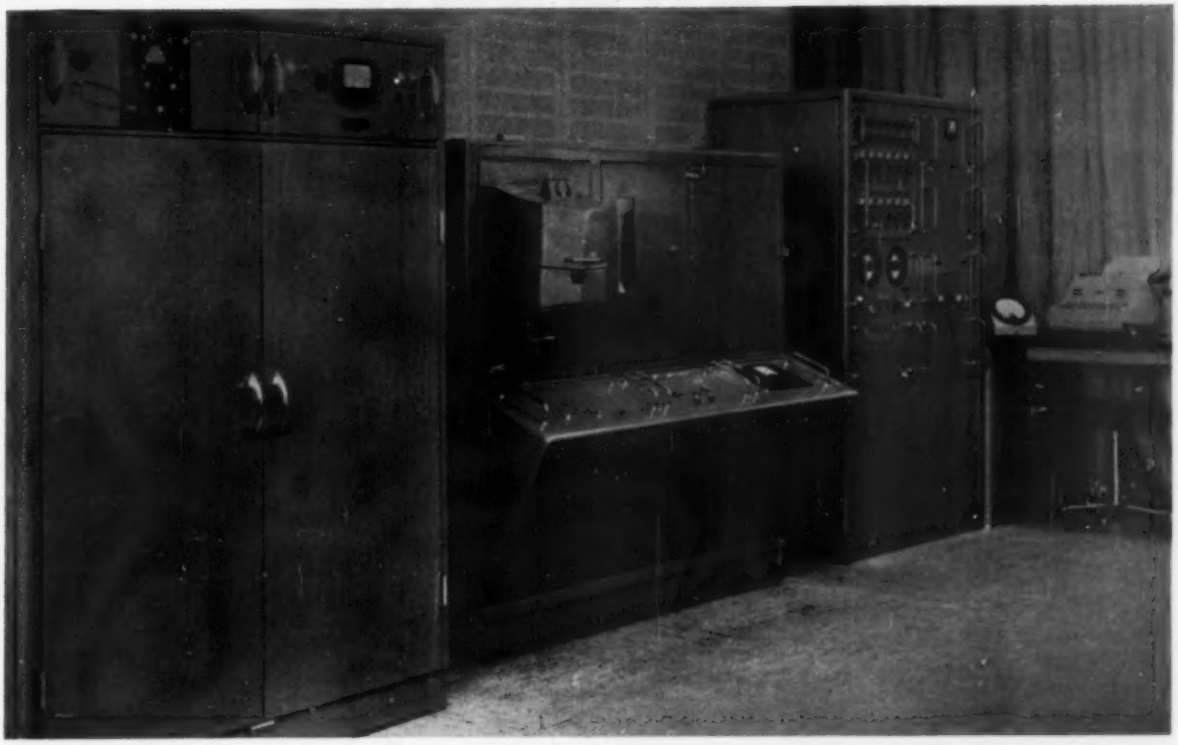

*The Polyvac-12 installed in the works of Mannesmann A.G., Germany*

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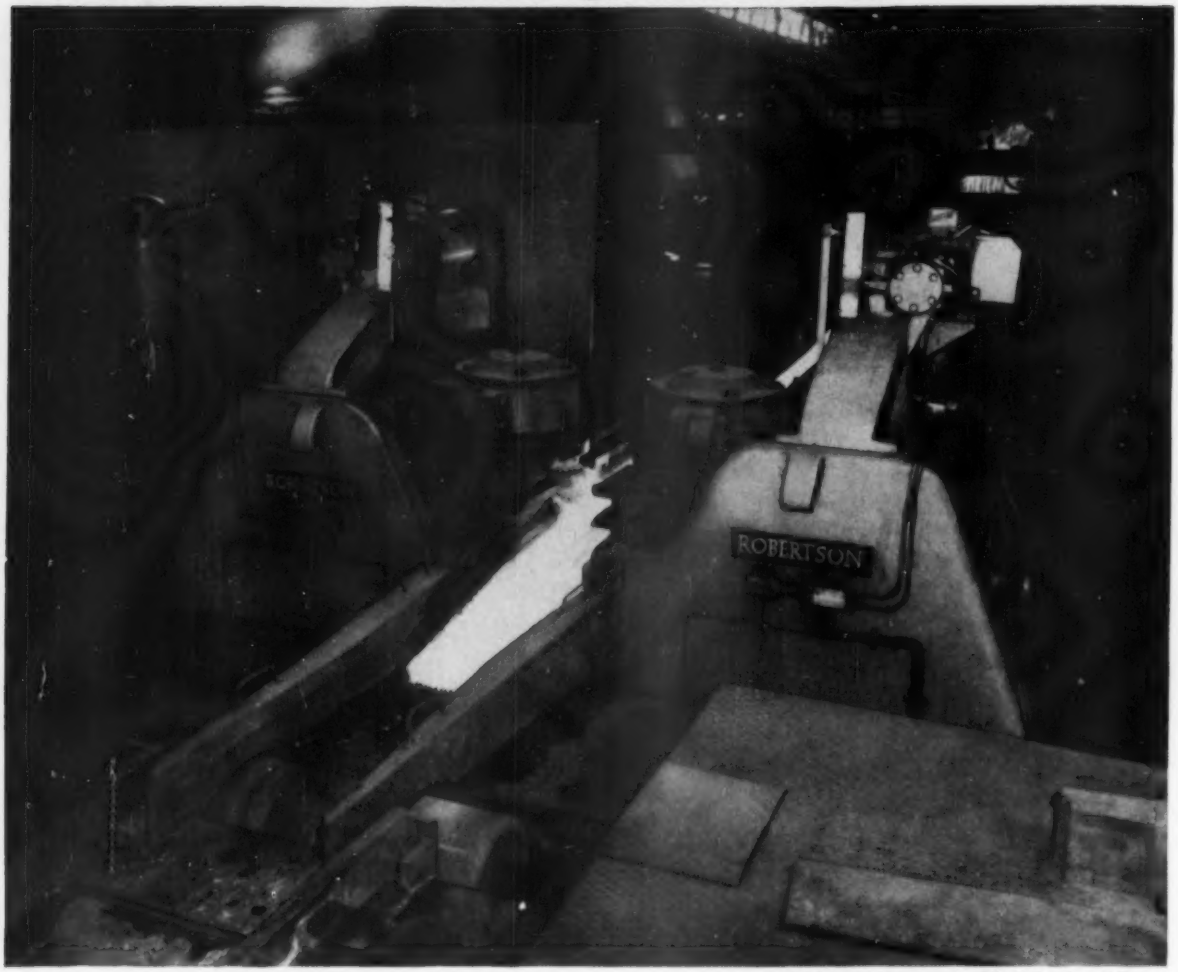


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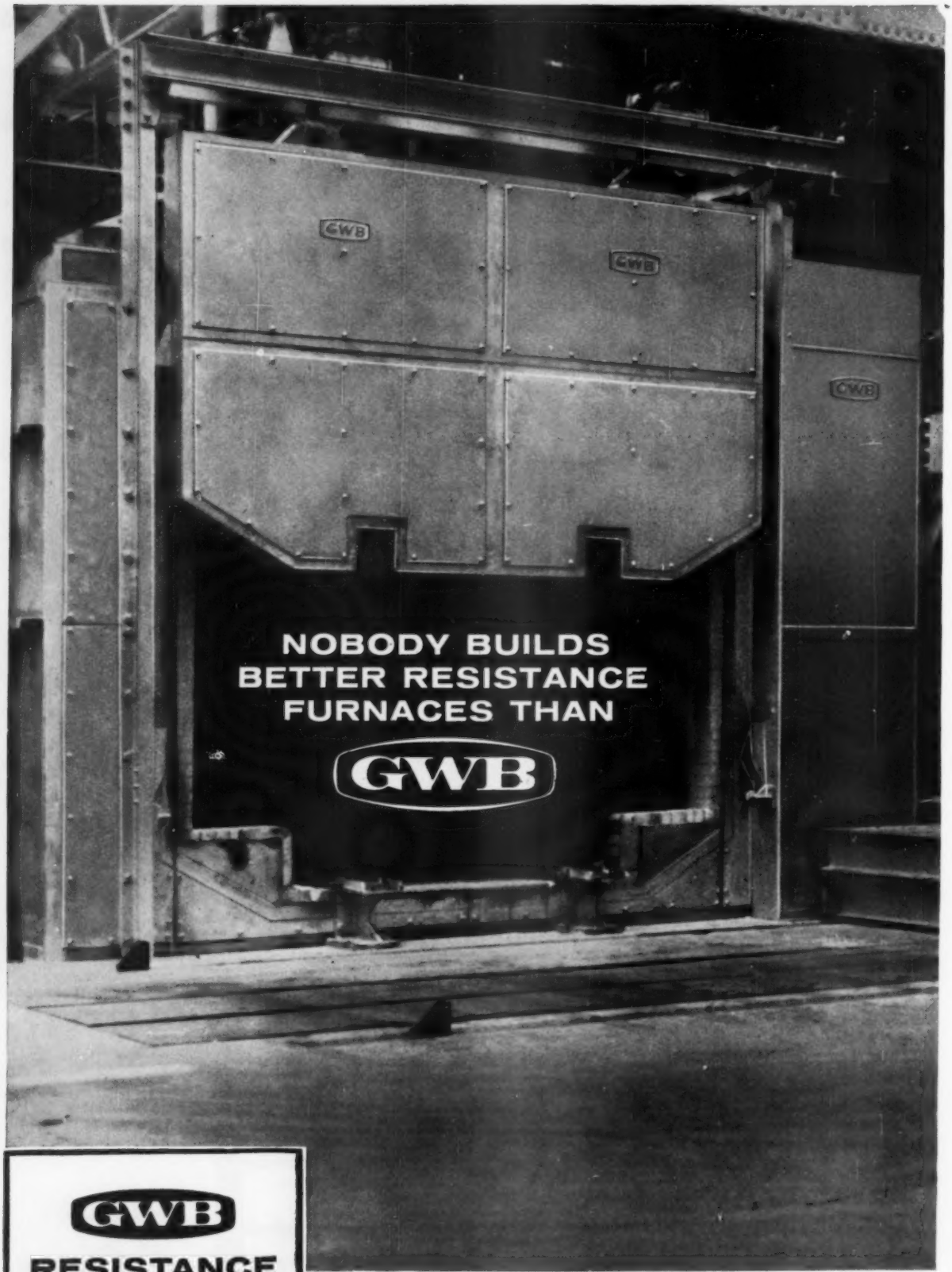


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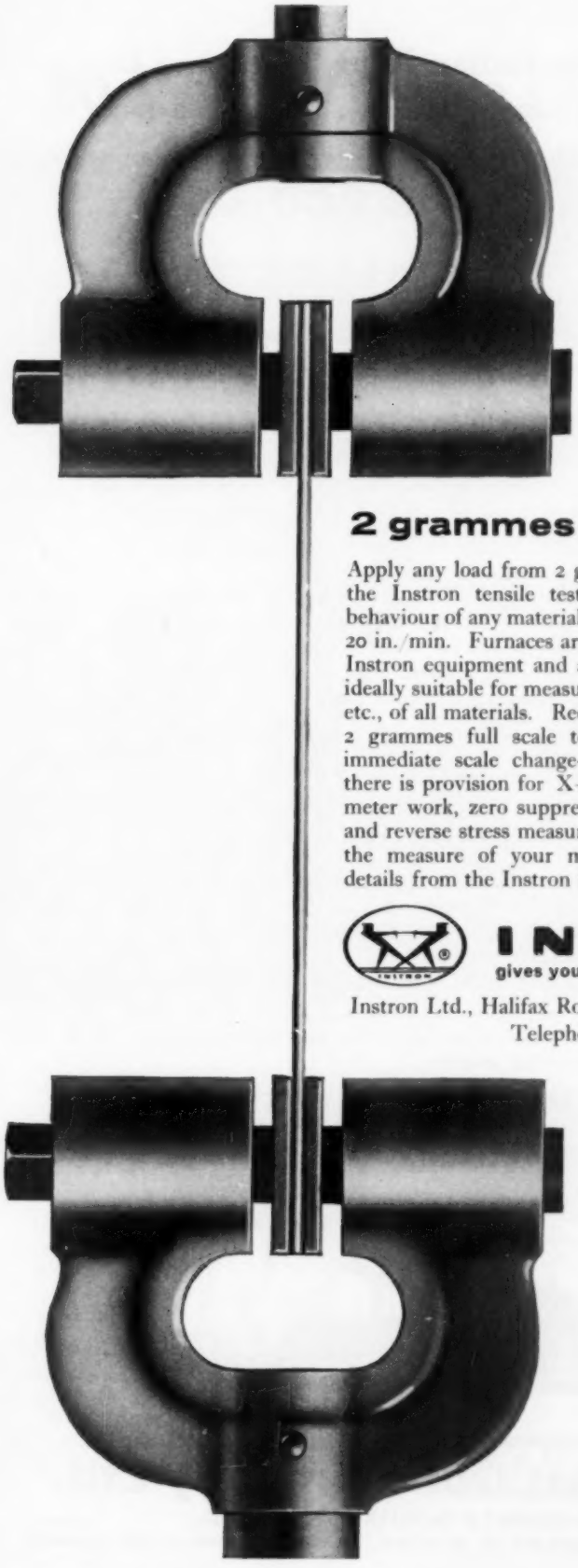

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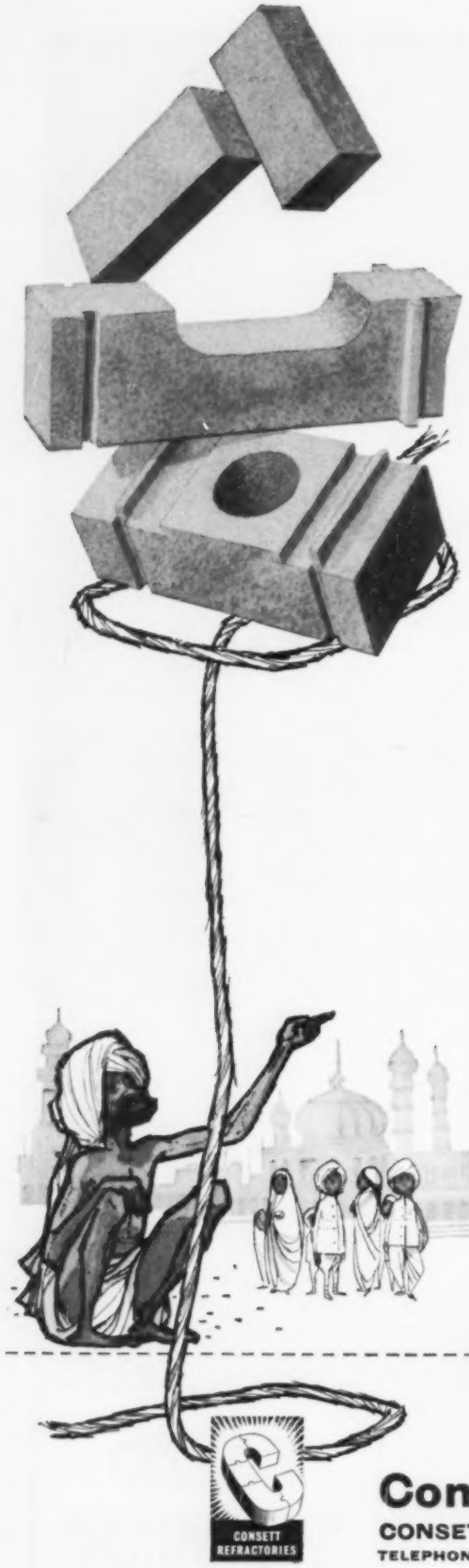

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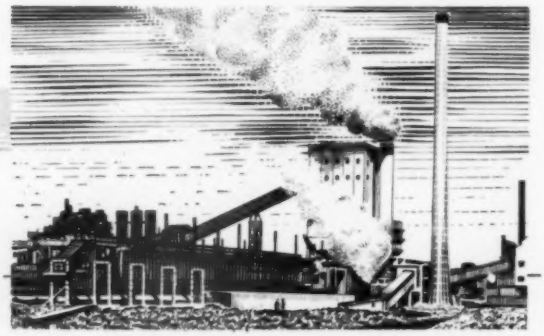

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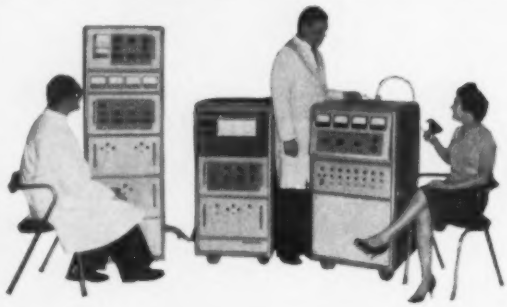

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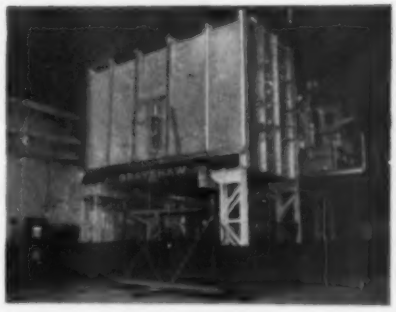

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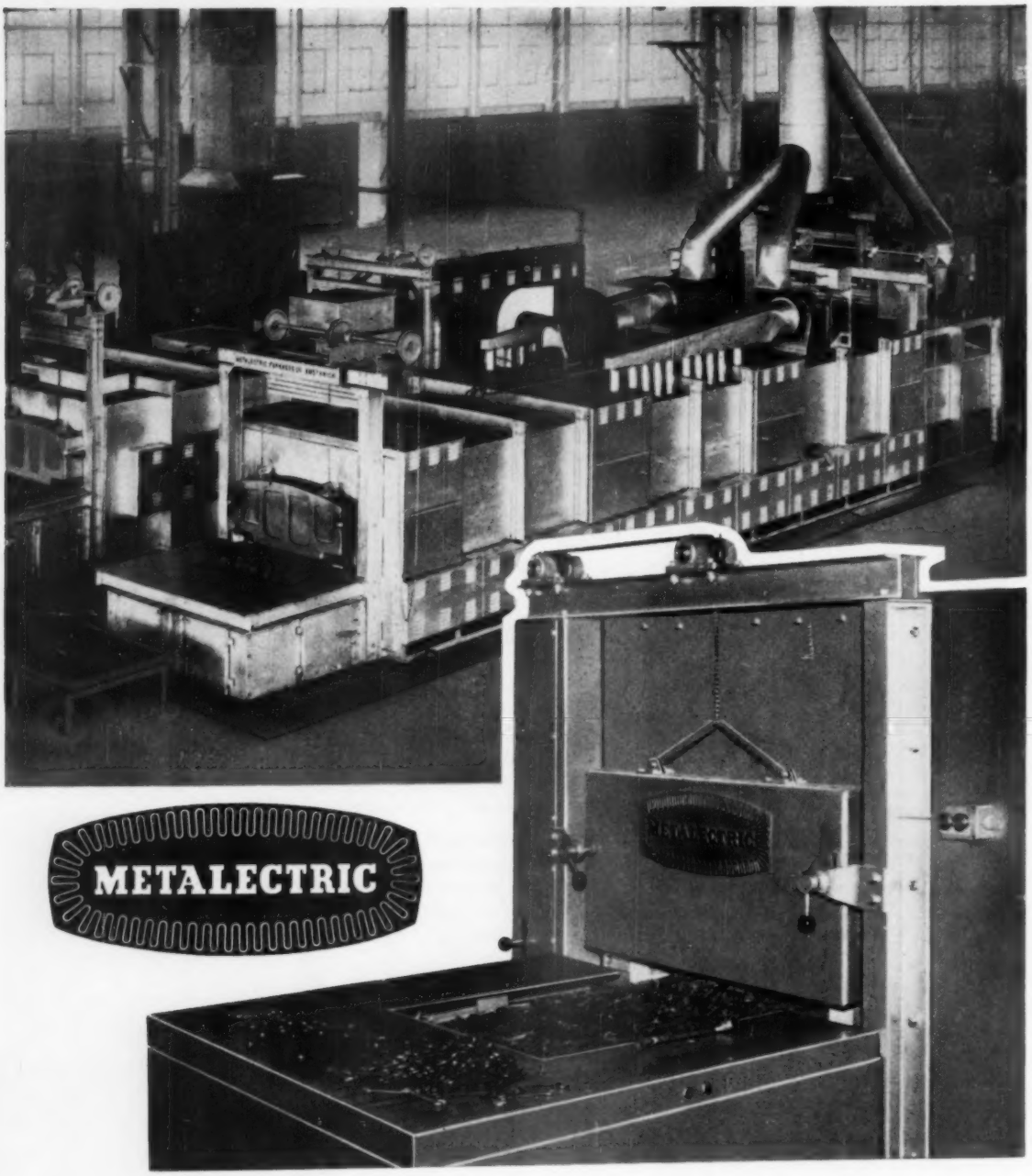

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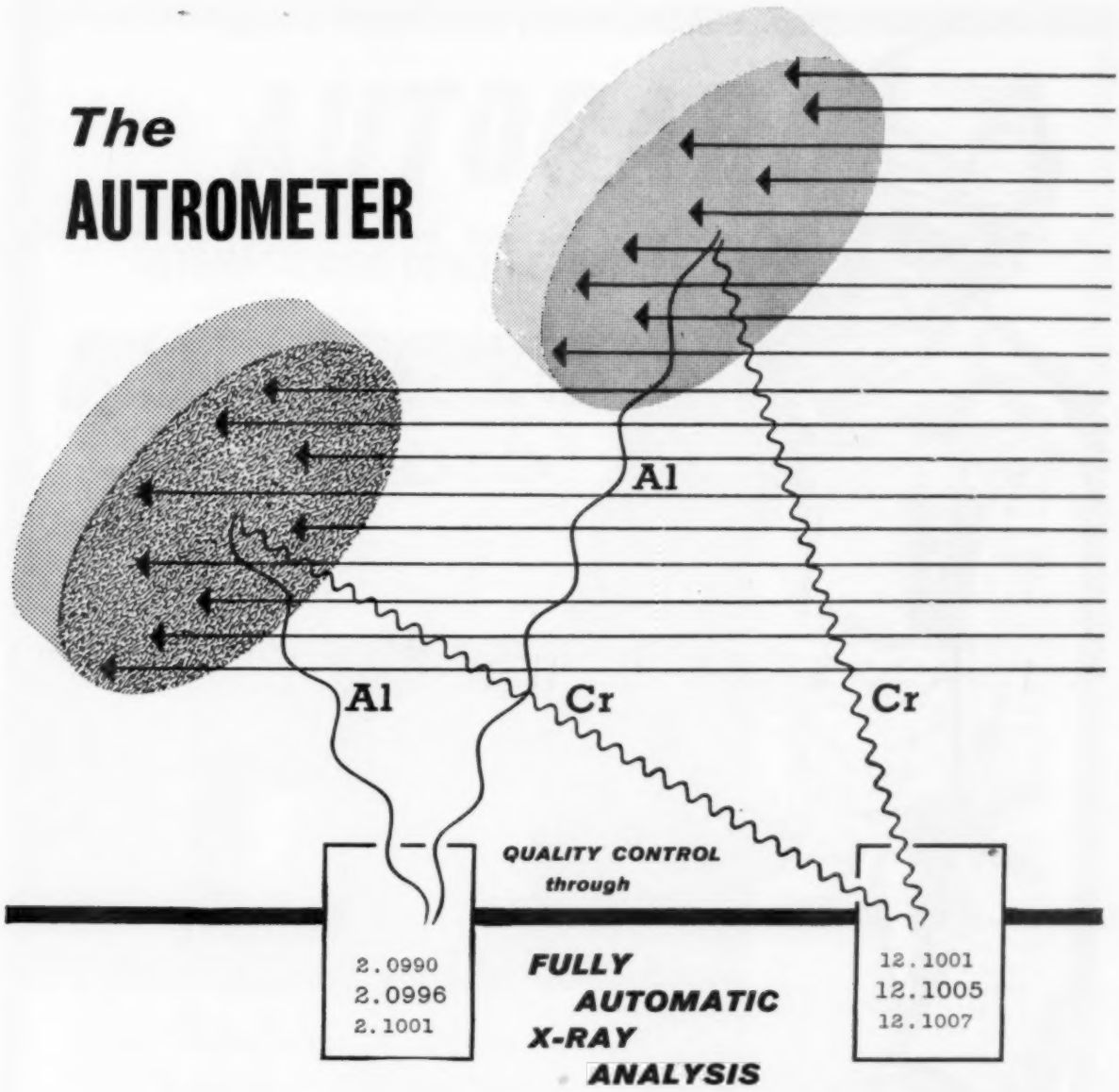


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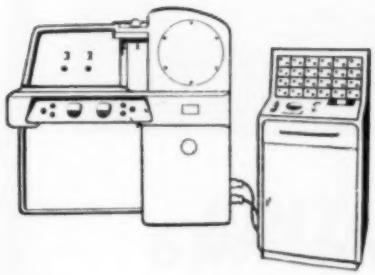

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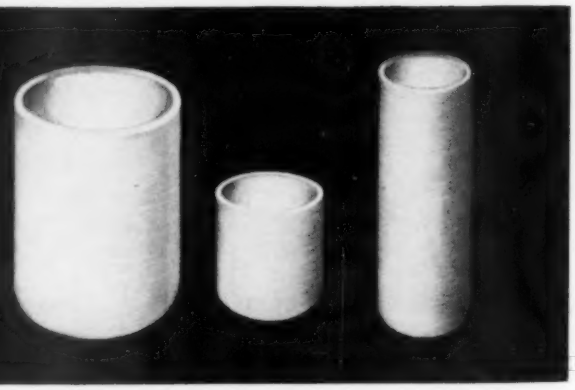

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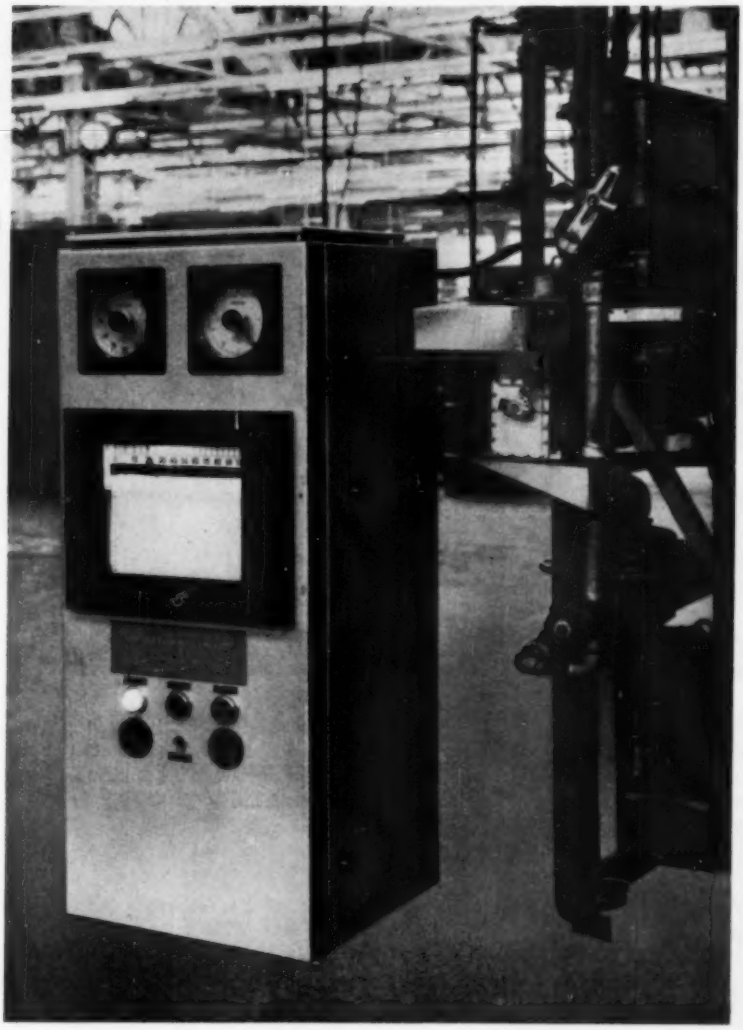

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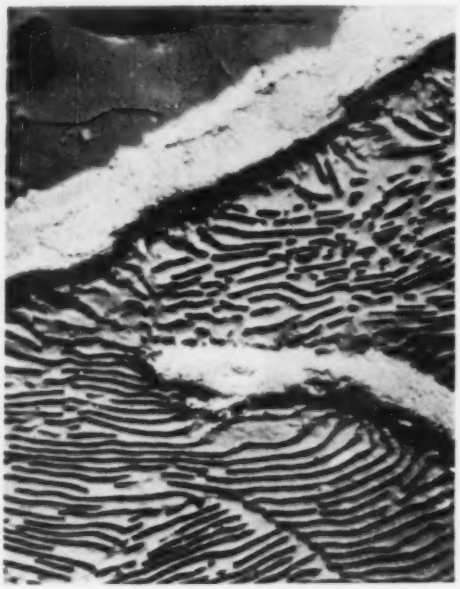

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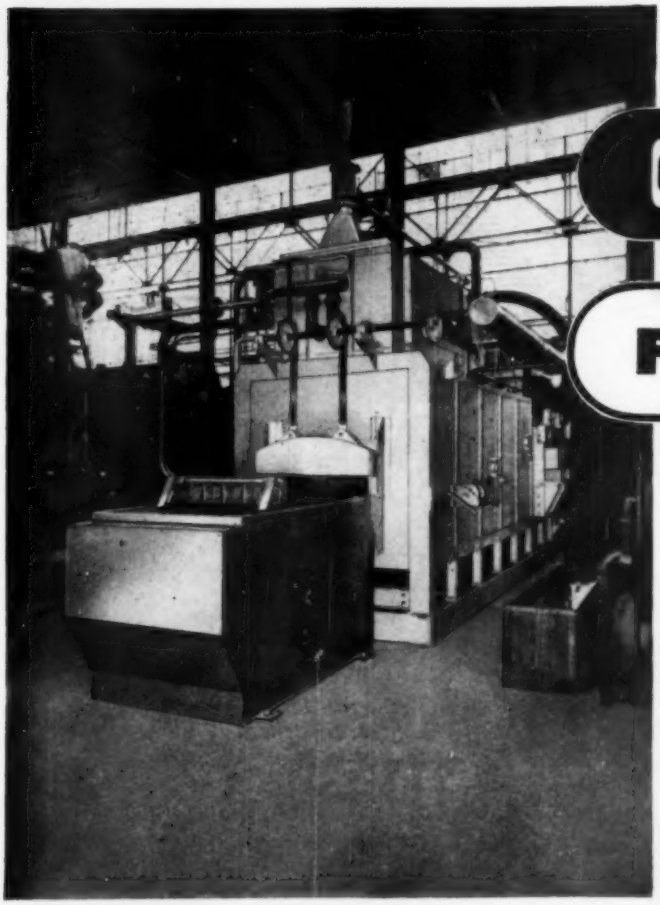

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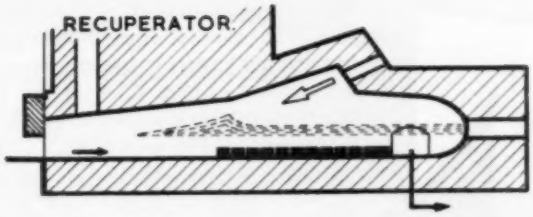


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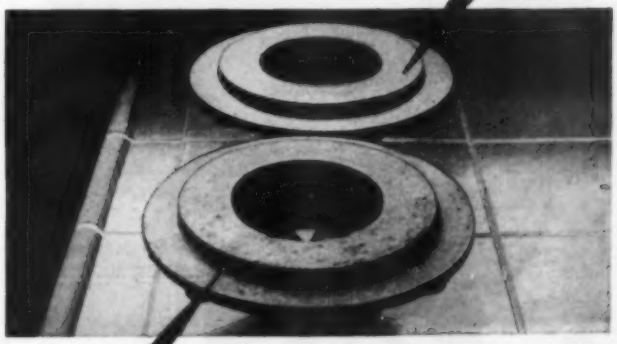

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THE BRITISH JOURNAL OF METALS
INCORPORATING THE METALLURGICAL ENGINEER

CONTENTS FOR NOVEMBER, 1961 Vol. 64 No. 385



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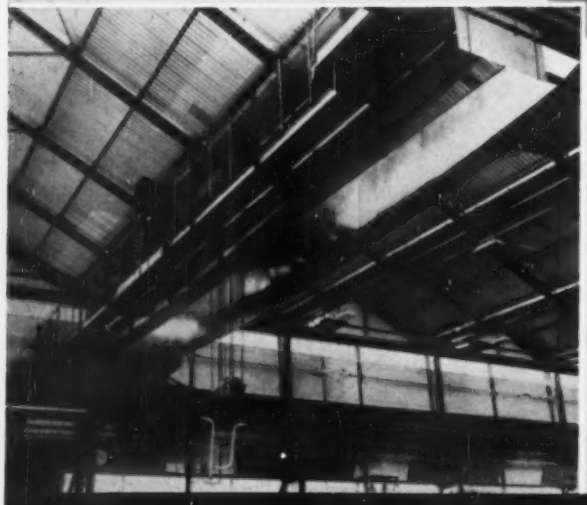

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INCORPORATING THE "METALLURGICAL ENGINEER"

NOVEMBER, 1961 Vol. LXIV. No. 385


## Management and Automation

"AUTOMATION starts with marketing and sales, for large scale production requires large markets. The salesman should not be a lone operator at the end of operations, for automation demands an integrated approach and a team effort on the broadest possible scale; the salesman must be inside the team instead of on the fringe. This does not demand so much a new kind of salesman as a revival of the old quality, for salesmanship becomes something of a lost art in days of easy selling. Unless the tempo of sales equals that of production, disaster can come more quickly than in a non-automated industry. The salesman will have to enter more intimately into design, marketing, merchandising, advertising and packaging, and all of these activities will need to be geared more precisely to the automated system."

The foregoing is an extract from an address on "Management on Automation" given by Mr. L. Landon Goodman at the recent National Conference of the British Institute of Management at Torquay, in the course of which he put forward some interesting points regarding automation, a few of which are outlined here.

The full technical implications of automation are now unfolding. There is, perhaps, a tendency to think of automation as applying to the monotonous manufacture of large numbers of one product, and this is to an extent true. On the other hand, in engineering and other fields, automation may have a large part to play in batch production, as is apparent in plate cutting in the shipyard and milling in the aircraft factory. That automation is already spelling variety has been apparent for some time—to some extent even with high degrees of mechanisation. An interesting example of this is provided by the Lorain production line of the Ford Motor Company, which produces twenty different models in solid colours and nine in two-tone combinations. It provides fifteen different engine and transmission combinations, and there are two types of heaters and radios, power seats, power windows and a host of other optional features. These give an almost unbelievable total of 776,355,840 different combinations of Ford car.

Many companies do little to extend the use of their products, and seem to rely entirely on a fortuitous approach from an imaginative and hopeful enquirer. It is surprising that large sums of money can be spent in developing a product and comparatively little in developing its utilisation to the full. Sales development is a method whereby markets for new and existing products can often be expanded considerably. It involves finding new uses for an existing article or developing new products which utilise the article: such work needs to be undertaken wholeheartedly if it is to be crowned with success.

In Mr. Landon Goodman's view, a feature of future competition will be the struggle among the leading industrial countries to become the primary centres of production. In the U.S.A. production of certain goods and products has tended to concentrate in certain areas, and the future scale of automation production in Europe may lead to similar concentrations. Where will Western Europe's steel centre be—in Sheffield, the Ruhr, or elsewhere? Where will its motor car manufacture be concentrated? If such concentration takes place, the answer to these questions will surely depend on who is quickest off the mark in adopting new and competitive methods, the most highly automated countries getting the business. In the meantime, manufacturers in particular industries could do much by exchanging information and co-ordinating expansion plans as is done at present in the steel industry."

It has been said that automation is a marriage of management and mechanism, with management as the senior partner. Certainly, if a firm is to have a progressive development strategy, its top management must have a general background understanding of science and sufficient knowledge of its own expanding technology to enable to be drawn the scientific/economic balance on which all major technological innovations depend. Management has to initiate, for it alone knows all the ramifications of its undertakings. In order to foresee possible applications of automation, it needs to understand automation and the advantage it confers. The responsibility rests with the management for initiating research and development, and surveys of the possibilities of automation; hence it has to educate itself continually to new methods of work.

Mr. Landon Goodman commended the idea of a local advisory panel as one which might well be developed. In each industrial area firms could be encouraged to join together to form local research and development group centres, staffed by scientists and engineers. The firms would provide a management panel which would allocate projects and consulting work from the various members according to priorities. No doubt emphasis at first would be placed on development work particularly in connection with production problems such as those related to low cost automation. Too many research reports are lying unused on too many shelves, and these local centres could usefully act as clearing houses for this type of information.

"Finally," said Mr. Landon Goodman, "a Department of Automation could do much to stimulate attention to these and many other matters, to sponsor research, to publish information and, possibly most important of all, to tie together many of the loose ends. An alternative is that the Ministry of Science should be strengthened. As this Ministry has only a very small staff, no one can dispute that it might well be strengthened, but whether it should have a Department of Automation under its wing is another matter. In order to flourish it seems essential that this proposed department should have the active support of trade unions and management as well as that of the Government."

# Meeting Diary

### 1st December

**Manchester Association of Engineers.** "Space Travel," by DR. R. C. JENNISON. Engineers' Club, Albert Square, Manchester, 2. 6.45 p.m.

### 4th December

**Institute of British Foundrymen, Sheffield & District Branch.** "Foundry Problems Associated with the Manufacture of Iron Rolls," by R. LEE. Annexe, Sheffield College of Technology, Pond Street, Sheffield, 1. 7 p.m.

**Institute of Metal Finishing.** Annual General Meeting and Second Annual Dinner. "The Changing Face," Presidential Address, by G. L. J. BAILEY. Hotel Russell, London, W.C.1. 2.30 p.m.

### 5th December

**Institution of Plant Engineers, Peterborough Branch.** "Non-Destructive Testing," by F. HINSLEY. Conference Room, F. Perkins, Ltd., Peterscourt, Peterborough. 7.30 p.m. Joint Meeting with the **Institution of Production Engineers.**

**Leeds Metallurgical Society.** "Dislocations," by PROF. J. NUTTING. University Staff House, University Road, Leeds. 6.30 p.m.

**Sheffield Metallurgical Association.** "Chemical Separations and the Use of Solvent Extractions," by W. E. CLARKE. B.I.S.R.A., Hoyle Street, Sheffield. 7 p.m.

### 6th December

**Institution of Structural Engineers.** "The Plastic Design of Steel Framed Structures," by PROF. M. R. HORNE. College of Science and Technology, Manchester, 1. 6.30 p.m.

**Institute of Welding, Manchester and District Branch.** "Improved Steels and their Weldability," by F. J. WILKINSON. 36, George Street, Manchester, 1. 7.15 p.m.

**Manchester Metallurgical Society.** "The Newer Magnetic Materials," by K. HOSELITZ. 36, George Street, Manchester, 1. 6.30 p.m.

**Society of Chemical Industry, Cathodic Protection Panel.** Discussion on Interference Testing, by J. H. GOSDEN and J. H. MORGAN. Society of Chemical Industry, 14 Belgrave Square, London, S.W.1. 6 p.m.

### 7th December

**Institute of Metals, Birmingham Local Section.** "Stress-Temperature Relaxation of Springs," by R. HAYNES. College of Technology, Gosta Green, Birmingham, 4. 6.30 p.m. (Joint Meeting with the **Birmingham Metallurgical Society.**)

**East Midlands Metallurgical Society.** "Metallurgy of Tungsten," by D. J. JONES. Faculty of Applied Science, Clifton Boulevard, The University, Nottingham. 7.30 p.m.

**Liverpool Metallurgical Society.** "The Explosive Forming of Metals," by H. THOMAS. Department of Metallurgy, The University of Liverpool, Liverpool, 3. 7 p.m.

### 7th and 8th December

**The Powder Metallurgy Joint Group of The Iron and Steel Institute and the Institute of Metals.** Winter Meeting, 1961. Church House, Gt. Smith Street, London, S.W.1.

### 8th December

**Institute of Physics and the Physical Society, Applied Spectroscopy Group.** "Recent Development on X-ray Fluorescence Spectroscopy," by J. L. DE VRIES. Royal Aeronautical Society, 4, Hamilton Place, London, W.1. 2.30 p.m.

**Institute of Physics and the Physical Society, Electron Microscopy Group.** Report on "Electron Microscopy in Japan," by T. MULVEY and M. WHELAN. 47 Belgrave Square, London, S.W.1. 2.30 p.m.

**Institute of Physics and the Physical Society, Non-Destructive Testing Group.** "The Correlation of Elastic Constants in Single Crystals and Polycrystals," by M. F. MARKHAM. 47, Belgrave Square, London, S.W.1. 6 p.m.

### 9th December

**Institute of British Foundrymen, Scottish Branch.** "Metallurgical Problems Associated with a Jobbing Foundry," by H. LONDON. Royal College of Science and Technology, Glasgow, C.1. 3 p.m.

### 11th December

**Institute of Metals, Scottish Local Section.** "Progress in the Electron Theory of Metals," by J. A. CATTERALL. Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, C.2. 6.30 p.m.

**Tyne Wear Metallurgical Association.** Short lectures by three members on: "Metallurgical Problems Encountered in their Work." Metallurgy Department, Kings College, Haymarket, Newcastle upon Tyne. 6.30 p.m.

### 12th December

**Institute of Metals, Oxford Local Section.** "Lattice Spacing Determination as a Tool in Metallurgical Research," by PROF. G. V. RAYNOR. Cadena Cafe, Cornmarket Street, Oxford. 7.15 p.m.

**Institute of Metals, South Wales Local Section.** "Some Theoretical Aspects of the Sintering of Metal Powders," by G. A. GEACH. Metallurgy Department, University College, Swansea. 6.30 p.m.

**Institute of Physics and the Physical Society, Stress Analysis Group.** Half day meeting on "Strain Gauges." 47, Belgrave Square, London, S.W.1. 2.30 p.m. Registration is necessary.

**Institution of Plant Engineers.** Film show—three films by British Railways. 36, George Street, Manchester, 1. 7.15 p.m. Ladies are invited.

**Sheffield Metallurgical Association.** Film Night. B.I.S.R.A., Hoyle Street, Sheffield. 7 p.m.

### 13th December

**Institution of Plant Engineers, East Midlands Branch.** "Repairs by the Metalock Process," by N. TINWELL. Sherwood Room, County Hotel, Theatre Square, Nottingham. 7 p.m.

### 14th December

**Institute of Metals, London Local Section.** "Feeding Non-Ferrous Metals Castings," by E. C. MANTLE. National Liberal Club, Whitehall Place, London, S.W.1. 7 p.m. (Joint Meeting with the **Institute of British Foundrymen, London Branch.**)

**Institute of Metals, Sheffield Local Section.** "Metals in the Jewellery Industry," by MISS D. L. PILE. Applied Science Building of the University, St. George's Square, Sheffield. 7.30 p.m.

**Institute of Physics and the Physical Society, Optical Group.** "A Zoom Stereoscopic Microscope," by T. A. MINNS. Imperial College of Science & Technology, Prince Consort Road, London, S.W.7. 2.30 p.m.

**Institution of Plant Engineers, North East Branch.** "Some Engineering Aspects of Recent Developments in the Iron & Steel Industry," by E. F. WOOLDRIDGE. Roadway House, Oxford Street, Newcastle upon Tyne, 1. 7 p.m.

**Southampton Metallurgical Society.** "Fatigue," by T. R. G. WILLIAMS. Southampton University. 7.15 p.m.

**West of Scotland Iron & Steel Institute.** "Operating Experience with an 80-ton Electric Arc Melting Furnace," by J. M. MOWAT, A. G. MCMILLAN and R. MCDONALD. Institution of Engineers and Shipbuilders in Scotland. 39, Elmbank Crescent, Glasgow, C.2. 6.45 p.m.

### 19th December

**Institute of Metals, Birmingham Local Section.** "Science in the Service of Metallurgical Industry," by H. MORROGH. Christmas Lecture for Schoolchildren. Large Lecture Theatre, Birmingham and Midland Institute, Paradise Street, Birmingham. 2.30 p.m.

**Sheffield Metallurgical Association.** "Vacuum Melting of Steels," by R. HALL. B.I.S.R.A., Hoyle Street, Sheffield. 7 p.m.

### 20th December

**Institute of Welding, West of Scotland Branch.** "Welding of Pipe Installations for Power Stations," by J. HAMMILL. Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2. 7 p.m.

**Society of Chemical Industry, Corrosion Group.** Discussion of recently published papers. Society of Chemical Industry, 14, Belgrave Square, London, S.W.1. 6 p.m.

# The Properties of Tungsten Carbide-Cobalt Alloys Used for Mineral Cutting Tools

By A. Latin, Ph.D., M.Eng., F.I.M.

*Head of Metallurgy Branch, Mining Research Establishment, National Coal Board*

*The work described by the author is a study of factors relevant to the cutting behaviour of cemented carbide hard metals in minerals, special attention being given to abrasion and to chipping at the cutting edges. The first part of this article deals with some of the relevant, fundamental properties of cemented carbides, and includes a description of the samples used for study, and of the method for the measurement of abrasive cutting wear.*

FIELD experience and trials on the use of cemented carbide hard metals for cutting coal or rock by rotary drill, percussive drill, cutter pick, etc., have indicated the need for a close metallurgical study of the materials used, with particular regard to the factors concerned in resistance to abrasion and to chipping at the cutting edges. In the course of such a study, test methods have been developed to investigate the abrasive wear characteristics and the " toughness " characteristics determining the resistance to chipping or to other forms of brittle fracture, and the relationship between such characteristics and composition and metallurgical structure have been considered. Before proceeding to an account of the experimental work, consideration will be given to some of the fundamental properties underlying the use of cemented carbides for the purposes outlined above.

## Basic Consideration

The hard metal materials with which the present work is chiefly concerned can be regarded as alloys of tungsten, carbon and cobalt. A detailed examination of this system has been carried out by Rautala and Norton,[1] who obtained equilibrium by sintering powder mixes at temperatures up to 2,000° C. The technical materials may more usually be looked upon as mixtures (or alloys) of tungsten monocarbide and cobalt, forming a quasi-binary system which may be represented by a suitable section of the ternary diagram. A simplified form of this quasi-binary, due to Sandford and Trent,[2] is shown in Fig. 1.

### *Constitution of Carbides*

Tungsten monocarbide is one of a series of hard compounds which comprise the carbides, borides, nitrides and silicides of the transition metals of Groups IV to VI of the Periodic Classification (tungsten, vanadium, tantalum, etc.). Truly accurate hardness values are difficult to obtain, but the diamond pyramid number of tungsten monocarbide may be taken as close to 2,500 kg./sq. mm., which may be compared with a figure of about 2,000 for sapphire and 10,000 for diamond[3] (corresponding Knoop microhardness values are 1,880, 1,800 and 6,000 respectively).

The exact causes of the great hardness of these compounds are not fully understood, although some interesting views have been put forward by Nowotny and Vitovec.[4]

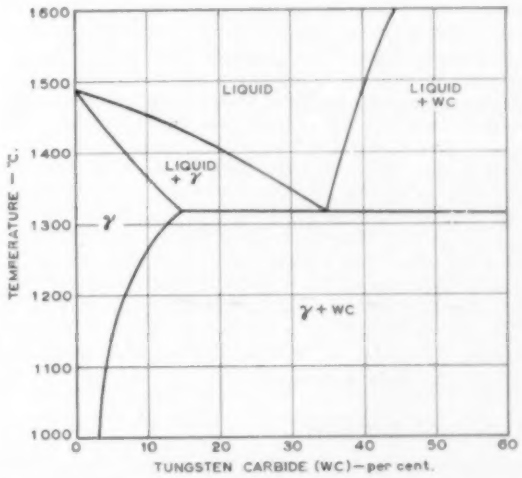



**Fig. 1.—Approximate pseudo-binary tungsten-carbide cobalt system (Sandford and Trent[2])**

As with diamond, the hardness must be connected with such factors as high melting point and high atomic characteristic frequency as well as with the presence of strong directional bonding : the intersititial position of the carbon atoms is doubtless also of importance.

### *Sintering Process*

Pure tungsten carbide itself is technologically unsuitable for tool purposes, both because of its high melting point (2,870° C.), which renders it difficult to cast or to sinter, and because of its brittleness. The difficulty of sintering is overcome by mixing with cobalt metal. As shown in Fig. 1, a eutectic is produced which melts at about 1,320° C., i.e. at a temperature much below the melting point of the carbide or of cobalt. In practice an intimate mixture of fine pure carbide powder and powdered cobalt (after pressing to shape, etc.) is heated in hydrogen or in vacuum at a temperature above 1,320° C. (following a lower temperature presinter). A certain amount of the tungsten carbide alloys with the cobalt, producing a corresponding amount of eutectic, which melts and brings about so-called " liquid-phase sintering," wetting and binding together the remaining

undissolved carbide particles. The exact temperature used depends upon the composition of the mixture; porosity can result from the use of incorrect temperature, whether too high or too low.[5] A contraction of about 20% occurs during sintering, entrained air escaping and diffusing out. The density of the resultant material is a good guide to correct sintering practice. The theoretical (maximum) densities can be calculated[2] by applying the simple mixture law, taking the density of tungsten monocarbide as 15·67(7) g./cc. and of cobalt as 8·89(0) g./cc. Actual densities are always less than theoretical, partly as the result of some residual porosity and partly because of the presence of impurity.

*Effects of Grain Size*

The initial tungsten carbide powder is produced in various grades, corresponding to various grain size ranges. Since the carbide is prepared by heating together tungsten metal powder and carbon, its grain size is closely related to the manner of production of the metal. The finest commercial grade of carbide produced may contain 90% of particles of less than 1 micron diameter, but coarser powders are normally used. Upon sintering, some recrystallisation and growth occur, readily detected from the rectangular shapes of the resultant grains. The presence of an undue proportion of such grains is undesirable if maximum hardness is required, and is an indication of over-sintering. In general the grain size of the product is rarely uniform; the predominating size may vary from less than 1 micron to over 6 microns. For a given cobalt content, the coarser the predominating grain size the softer the alloy. The grain size may also have a considerable effect upon the resistance to shock and related properties, and the blending of grains of a range of sizes is sometimes favoured in this connection.[6]

*Effects of Cobalt Content*

The amount and manner of distribution of the cobalt in the final alloy are of great importance. The cobalt, which must be of high purity, is mixed with the carbide (usually as fine metal powder, although sometimes added as oxide) by prolonged milling. If local accumulations of unmixed cobalt occur, these can be a serious source of weakness. Cobalt "lakes" may also result from incorrect sintering practice. In addition to the important part it plays in the sintering process, the cobalt present probably plays the main part in enabling the material to withstand some degree of deformation. The alloys may be looked upon as a matrix of relatively soft cobalt in which the hard carbide grains are dispersed, although in the compositions here concerned many grains must be contiguous. Another picture is that of an interpenetrating network of carbide and cobalt. This latter view has been favoured by Dawihl and Hinnuber,[7] from investigations which indicated that the cobalt could be dissolved away, leaving a carbide skeleton of considerable strength, indicating strong carbide-carbide bonds. To some extent their results have been supported by Redmond,[8] but Gurland and Norton[9] concluded that the mechanical properties of the cemented carbides can best be understood on the basis of the effects of the cobalt matrix. Such a picture enables some qualitative understanding to be gained of the effect of cobalt content and of grain size, since, for a given composition, the smaller the grain size the thinner and less readily deformable are the cobalt interlayers.

Gurland *et al*[10] have related the effect of the cobalt to the mean free path between the carbide grains on the view that this is the operative thickness of the plastic layer between the restraining hard particles. This has enabled some understanding to be gained of the effect upon hardness and transverse rupture strength, but the relationship to fracture or chipping under impact is less clear. It may be noted that very little plastic deformation takes place in these materials before fracture; Lardner and McGregor[11] have stated that at least 13% cobalt is needed for appreciable plastic deformation of the alloy as a whole to be possible, but it seems probable that the actual cobalt content concerned is dependent upon grain size.

*Effects of Carbon Content*

The theoretical carbon content of pure tungsten monocarbide is 6·12%. If the actual carbon in the carbide/cobalt alloys differs notably from the theoretical, undesirable effects may occur. An excess of carbon, for example, can result from the carbonising action of graphite containers or carbon powder used as a cover in sintering, the alloy then containing uncombined carbon as graphite particles, usually in clusters ("rosettes"). Brownlee and co-workers[12] have shown that an undue amount of free carbon (0·2%) can markedly decrease the resistance to rupture. More important is the possible effect of a deficiency of carbon, resulting in the presence of the $\eta$-phase constituent. This is a compound containing cobalt as well as tungsten and carbon, sometimes given the formula $Co_3W_3C_4$, and it is extremely brittle. Even a deficiency of carbon of only 0·05% is highly undesirable.

*Effects of porosity*

In some respects the effect of porosity may be looked upon as similar to that of an excess of carbon, and a tentative specification including "free-carbon porosity," based upon the examination of polished sections at moderate magnification, has been proposed by the American Society for Testing Materials.[13] There are few published data on the exact effects of porosity; Redmond[8,14] has reported a 57% decrease in the transverse rupture strength of an alloy containing 6% cobalt, as a result of increased porosity from 0·9% voids to 2·6% voids.

*Mechanical and Physical Properties*

The tensile strength of the cemented carbides is not outstanding in spite of the high hardness. The compressive strength on the other hand is very high, having values in the range 200 tons/sq. in. to 350 tons/sq. in., increasing with decreasing cobalt content.

An outstanding property of tungsten carbide is its very high elastic modulus: that of the pure carbide at 20° C. has been reported as being $102·5 \times 10^6$ lb./sq. in.[15] The value decreases with added cobalt, being about $88 \times 10^6$ lb./sq. in. with 6% cobalt and $82 \times 10^6$ lb./sq. in. with 15% cobalt in the alloy[11,16]. Thus, values nearly three times that of steel are possible, and it is partly for this reason that it is usually recommended for carbide-tipped tools that the steel backing should have several times the thickness of the carbide,

to minimise the stresses in the latter (especially important with the carbide in tension).

The coefficient of thermal expansion is considerably less than for steel, being in the range $3-7{\cdot}5 \times 10^{-6}$/° C.[8,16] as compared with a range for steel of about $11-12 \times 10^{-6}$. This difference is important in connection with the brazing of carbide tips on to steel shanks; considerable stresses can be set up by differential contraction on cooling, and great care must therefore be taken. The use of a thick braze is often recommended, with a layer of soft iron or brass mesh included, this allowing a certain amount of plastic deformation and therefore of stress relief. In addition the thicker the carbide tip the more the stresses are evened out.

The effect of temperature upon the hardness of tungsten-carbide/cobalt compositions is of some interest. No sudden softening occurs but a general decrease of hardness with temperature. For example, according to figures given by Dawihl,[17] the hardness might decrease about 500–700 kg./sq. mm. in diamond pyramid value at 700° C., a temperature which might well be attained at the tips of some cutting tools.

Although tungsten carbide is non-magnetic, the magnetic properties of the cemented carbide are of considerable interest. In particular the coercive force depends not only upon the proportion of ferromagnetic material (cobalt, etc.) but also upon the grain size and other factors, and its measurement is used to a considerable extent for control of the sintering process.

TABLE I.—TYPICAL ANALYSIS AND GRAIN SIZES OF CARBIDE SAMPLES

| Grain Size Designation | Nominal Average Cobalt Content (wt.-%) | Analysis (wt.-%) | | | Predominant Grain Size Range (micron) | Approximate Mean Free Path (micron) |
|---|---|---|---|---|---|---|
| | | Cobalt | Total Carbon | Free Carbon (where determined) | | |
| Fine | 4 | 3·9; 3·8 | 5·95; 6·1 | 0·09 | 1–2 | 0·1 |
| | 6 (*i*) | 5·7; 5·8 | 5·7; 5·8 | 0·02; 0·04 | 1–2 | 0·15 |
| | (*ii*) | 5·7; 5·9; 6·0 | 5·8; 5·9; 5·7 | 0·07; 0·09 | 1–2 | 0·15 |
| | 7 (*i*) | 6·7 | 5·8 | — | 2 | 0·25 |
| | (*ii*) | 6·8; 6·3 | 5·45; 6·0 | 0·02; 0·08 | 1 | 0·12 |
| | 10 (*i*) | 9·5; 9·6 | 5·7; 5·8 | 0·08; 0·14 | 1 | 0·17 |
| | (*ii*) | 9·6 | 5·62 | — | 2–3 | 0·3 |
| | 12 (*i*) | 11·9; 11·8 | 5·5; 5·6 | 0·09; 0·08 | 1–3 | 0·4 |
| | (*ii*) | 11·5 | 5·4 | — | 1–2 | 0·3 |
| | (*iii*) | 12·4 | 5·4 | — | 1–2 | 0·3 |
| | 13 | 12·9 | 5·3 | — | 1 | 0·25 |
| | 14 | 13·1; 13·4 | 5·4; 5·7 | 0·09; 0·1 | 1–2 | 0·4 |
| | 20 | 18·9; 19·8 | 5·1; 5·3 | 0·07; 0·08 | 1–2 | 0·6 |
| Medium | 4 (*i*) | 3·7; 3·85 | 5·9; 6·1 | 0·09; 0·09 | 2–3 | 0·15 |
| | (*ii*) | 4·9 | 5·9 | — | 3–4 | 0·25 |
| | 5 | 4·7 | 6·0 | 0·11 | 3–4 | 0·3 |
| | 6 (*i*) | 5·7; 6·0 | 5·9; 5·8 | 0·13; 0·10 | 2–3 | 0·25 |
| | (*ii*) | 6·2 | 5·8 | — | 3–4 | 0·35 |
| | (*iii*) | 6·6 | 5·7 | — | 3–4 | 0·35 |
| | 7 | 6·3; 6·5 | 5·6; 5·8 | 0·01; 0·02 | 1–3 | 0·35 |
| | 8 | 8·0 | 5·5 | — | 2–3 | 0·35 |
| | 9 (*i*) | 8·5 | 5·3 | 0·01 | 2–3 | 0·4 |
| | (*ii*) | 8·6 | 5·6 | — | 2–3 | 0·4 |
| | 10 | 9·6; 9·7 | 5·7; 5·8 | 0·18; 0·07 | 2–3 | 0·45 |
| | 11 (*i*) | 10·1; 9·8 | 5·2; 5·6 | 0·01; 0·04 | 2–3 | 0·45 |
| | (*ii*) | 10·9 | 5·4 | — | 2–3 | 0·5 |
| | 12 (*i*) | 11·7; 11·6 | 5·55; 5·7 | 0·2; 0·12 | 2–4 | 0·6 |
| | (*ii*) | 12·5 | 5·4 | — | 3–4 | 0·7 |
| | 13 (*i*) | 12·0; 11·9 | 5·2; 5·5 | 0·01; 0·03 | 1–3 | 0·5 |
| | (*ii*) | 12·9 | 5·3 | — | 2–3 | 0·6 |
| | 14 | 13·4; 13·8 | 8·6; 5·4 | 0·21; 0·08 | 2–4 | 0·7 |
| | 16 | 15·5 | 5·1 | — | 2–3 | 0·75 |
| | 20 (*i*) | 19·6; 19·0 | 5·3; 5·0 | 0·1; 0·07 | 2–4 | 1·2 |
| | (*ii*) | 18·5 | 4·9 | — | 2–3 | 1·0 |
| Coarse | 4 | 3·0 | 5·9 | — | 4–8 | 0·4 |
| | 9 | 8·9; 8·5 | 5·4; 5·7 | 0·01; 0·02 | 3–5 | 0·7 |
| | 10 | 11·1 | 5·5 | — | 5–6 | 1·0 |
| | 11 (*i*) | 10·4; 10·0 | 5·2; 5·6 | 0·01; 0·03 | 3–5 | 0·8 |
| | (*ii*) | 10·4 | 5·4 | — | 3–5 | 0·8 |
| | 12 | 11·8 | 5·4 | — | 4–5 | 1·0 |
| | 15 | 14·7 | 5·3 | — | 2–4 | 1·0 |
| | 20 | 19·0 | 5·3 | — | 3–6 | 2·0 |

Note: the subsections (*i*), (*ii*) for each grade represent samples from different sources; several different supplies are in all represented.

### *Resistance to Fracture*

The resistance to fracture of these materials is usually assessed by the transverse rupture strength. This may be of the order of $200-400 \times 10^3$ lb./sq. in. According to the results of Gurland and Bardzil,[10] maxima are reached at certain grain sizes and cobalt contents corresponding to values of the mean free path between 0·3 and 0·6 micron. The present work is more closely concerned with fracture of the form of chipping at the front cutting edge or on the working face of tool tips, and impact is probably frequently involved.

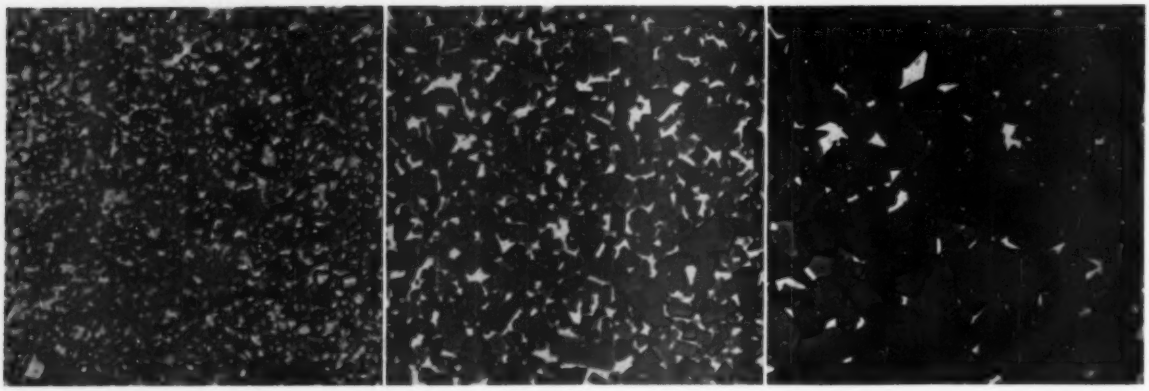
The resistance to fracture as determined by the energy absorbed in impact is small, but increases with increasing cobalt content. Engle[18] has reported impact values for unnotched $\frac{1}{4}$ in. square section test pieces of 0·73 ft. lb. with 6% cobalt, increasing to 1·75 ft. lb. with 20% cobalt in tungsten carbide alloys. Lardner and McGregor[11] have determined the fracture energy in the bending of 0·25 in. × 0·1 in. section test pieces over a 5 in. span as being within the range 0·23 ft. lb. for a 6% cobalt alloy to 0·06 ft. lb. for a 20% cobalt alloy. High cobalt contents and coarse-grained alloys are in practice required for maximum "toughness," and the poor fracture resistance is the reason that carbide tool tips usually have large included angles at the cutting edges.

### *Alternative Compositions*

Other binding metals may be used instead of cobalt, notably iron and nickel, but are less satisfactory. This is partly because they retain a greater amount of carbide in solid solution on cooling after sintering: the films of the binder metal are thereby harder and more brittle, and so less effective than cobalt in improving toughness by allowing plastic deformation.[2]

The tungsten carbide may also be replaced to a greater or lesser extent by other carbides. For the purposes with which the present work is concerned, none would appear, as far as is known,[2] to have as good a combination of properties, although small percentages of tantalum carbide or other carbides are sometimes added for grain growth inhibition and other reasons. Additions of titanium carbide, as for steel-cutting grades, are undesirable for the present purposes because of increased embrittlement, and are unnecessary since there is no "cratering" behind the cutting edge.

The effects of possible impurities are also of great importance. A common impurity is iron and, whilst the precise effects of its presence are not known exactly, the amount allowed must be strictly controlled.



(a) Fine-grained : predominant grain size 1 micron. (b) Medium-grained : predominant grain size 2-4 microns. (c) Coarse-grained : predominant grain size 6-8 microns.

**Fig. 2.—Some structures of carbide specimens (× 1500). For coarse-grained specimens in general the predominant grain size was below 6 microns.**

## Materials Used for Experimental Work

*Compositions, Grades and Forms of Carbide Specimens*

The specimens used included cobalt contents ranging from 4 to 20%, obtained from various manufacturers. Table I includes a list of the chief compositions used with some typical analyses of cobalt and carbon. In the other tables and in the text which follows, letters represent the designated grain size (F representing "fine," C "coarse" and M "medium") and the figures following the letters represent nominal average cobalt percentages (rounded off to whole numbers).

The exact definition of the grain size of the sintered alloys offers difficulties owing to the large variation that may occur in a given material. The grain size can be estimated by the counting of grains on photomicrographs at suitable magnification, but the method is cumbersome and subject to considerable inaccuracy. For practical purposes the estimation of a "predominant" grain size (or range) is simpler and probably more useful. A diagram originated by Miller[19] for comparison with grains in photomicrographs at 1,500 diameters magnification has been used in the present work. Table I includes results on a random set of samples together with some approximate calculated values of the mean free paths.[10] Photomicrographs in Figs. 2*a*, *b* and *c* show structures of fine, medium and coarse-grained carbides from the different series.

The specimens employed have been mainly of rectangular form, $\frac{3}{4}$ in. × $\frac{3}{4}$ in. × $\frac{1}{4}$ in. (weight about 8 g.) and $\frac{7}{16}$ in. × $\frac{11}{32}$ in. × $\frac{1}{4}$ in. (weight about $4\frac{1}{2}$ g.). For the abrasive wear tests the section at one of the shorter edges was ground back 20°, i.e., to an included angle of 70°. This is the same cutting edge angle as that used for the tips of rotary drills for coal boring. For the chipping tests a somewhat smaller included angle (actually 62°) was used. Various samples taken from actual tips or from complete bits and picks, etc. from various sources, were also examined.

*Hardness Measurements*

A large number of diamond pyramid hardness tests were carried out (at 30 kg. load) on the range of specimens under investigation. It has not been possible to determine actual cobalt contents of all samples concerned, and the hardness values shown in Fig. 3 are plotted against both actual cobalt contents (where determined) and nominal cobalt contents. For the latter the range of observed values rather than individual values is indicated. The curves shown indicate approximate mean values for each of the three main ranges of grain size. There are considerable difficulties in the accurate measurement of hardness of these substances, especially at the higher ranges, because of the smallness of the impressions and the incidence of cracking at the corners. The values given were mostly obtained on polished cross sections, and do not include those for which cracking unduly interfered with accuracy of measurement.

It will be seen that HV30 hardness values ranged from about 1,850 to 1,100 in the fine grain material, from 1,600 to 1,000 in the medium grain material, and from 1,350 to 900 for the coarse grain material. For a given grade the overall variation in value was approximately of the order of ± 50.

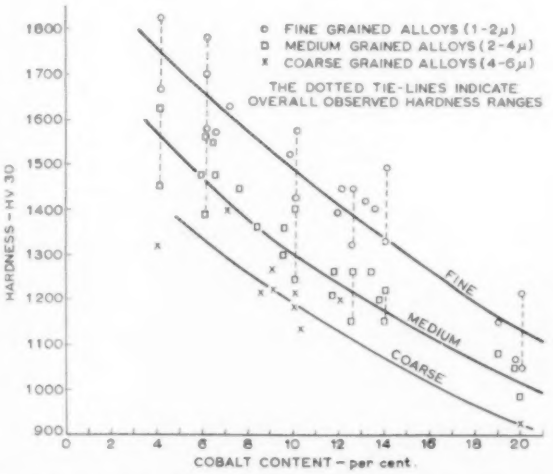



**Fig. 3.—Variation of hardness with cobalt content.**

*Density Measurements*

A large number of density measurements were also carried out on the same specimens. Again there were considerable observed variations. The results are shown plotted in Fig. 4 chiefly against nominal cobalt content (against actual cobalt values where analysis was available), and are compared with the curve for the theoretical density. All the measured values were of reasonable order, indicating in general no unduly great porosity, although some of those deviating most from the theoretical values contained considerable free graphite. Examination of polished sections indicated a considerable variation in apparent porosity including A.S.T.M.[13] types A (small pores) 1–4 (i.e. ranging from slight to medium in amount), B (larger pores) 1–3, and some C (free graphite). However, the apparent porosity in general did not appear to be excessive.

## Experimental Work

This included studies of abrasive wear in cutting rock, of the effects of impact against rock, and some transverse rupture and other tests.

*Studies of Abrasive Wear*

Various methods exist for the determination of the resistance to abrasive wear of materials. In general, subjection to the action of a suitable abrading substance is required, under specific conditions of load or pressure and of velocity. A review of the subject has been given by Haworth,[20] who has described in particular the use of an apparatus based on the abrasive action of particles carried against and across a loaded metal specimen by means of a rubber wheel. Abrasion testers using diamond powder[21] have also been used for studies on cemented carbides. Other special tests have been described by Schwarzkopf and Kieffer.[22] For the present purpose, the study of wear losses at tool edges in an actual machining test under standard conditions of tool angle, depth of cut, speed, etc., is of more value. A difficulty is that whilst it is possible in some circumstances to determine the forces operating on a cutting edge,[23] such estimation is very difficult in the cutting of materials such as rock or coal. Three main ways of estimating actual wear loss offer themselves, namely (*i*) by measurement of dimensional alterations of the tool tip, e.g. the wear flat; (*ii*) by determination of the loss of weight; and (*iii*) by the use of radioactive tracers.[24] Method (*ii*) is the most direct if the weight losses are sufficient for accurate measurement and the wear sufficiently uniform, and was the one chiefly used in this work.

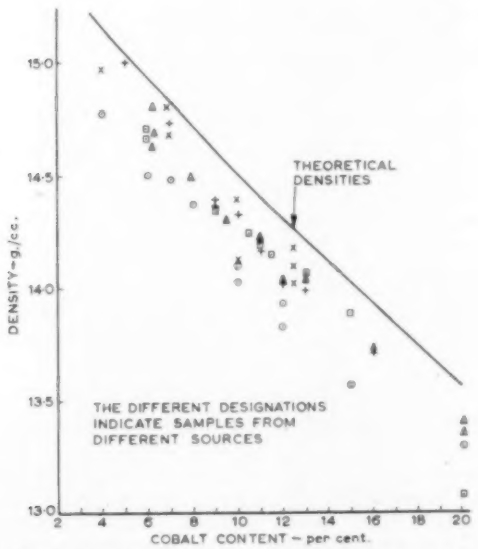



**Fig. 4.—Variation of density with cobalt content**

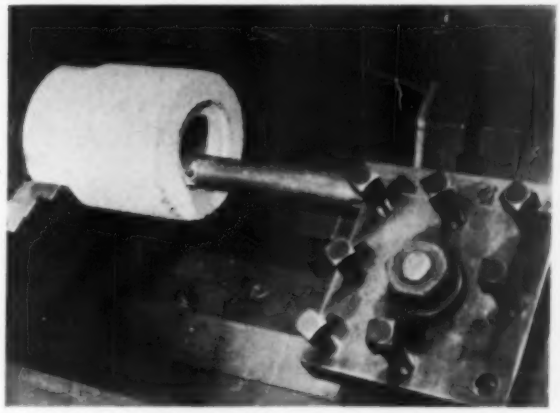


**Fig. 5.—Wear test apparatus—end cuts.**

*Rock Samples*

The rock used was sandstone from Darley Dale, Derbyshire, a source known to be of very uniform quality; this stone is also highly abrasive, although readily cut. Samples were obtained chiefly as 4 in. diameter cores.

*Details of Methods Used*

The rock sample was held in the headstock of a lathe, a hole of approximately 2 in. diameter having first been drilled through the centre. The test consisted of taking standard cuts around this hole at a standard speed of rotation of the rock. The cuts were taken either (*a*) along the inner wall, or (*b*) normal to the end face.

The carbide sample was mechanically held in a holder so devised that the sample could be readily removed for weighing but was nevertheless held very firmly for cutting. In method (*a*) this holder was fitted at right angles into a rigid steel boring bar held in the lathe tool post, so that the cutting edge of the tip was parallel to the axis of the rock core. The rock was rotated and a cut taken along the inner wall using the automatic traverse of the lathe. In method (*b*) the edge of the tip was parallel to the end face of the core and a step equal to the width of the tool was cut around the hole at constant automatic lathe feed. The normal force on the tool could be recorded by means of a resistance strain gauge load cell. This method resulted in more uniform wear along the tip edge than obtained with method (*a*). Wear was expressed as the loss of weight per unit area of rock surface traversed.

The area traversed ($A$) is given by : for side cuts

$$A = \pi d\,(l - \tfrac{1}{2} b)\, b/\delta,$$

where $d$ = hole diameter
$l$ = length of cut
$b$ = width of tip
$\delta$ = feed per revolution

and for end cuts

$$A = \pi b\,(d_1 + d_2)\, nt/2,$$

where $d_1$, $d_2$ = initial and final hole diameters
$n$ = rotation rate
$t$ = time of test

For the side cuts a lathe setting corresponding to a feed ($\delta$) of 0·0138 in./rev. gave a reasonable order of rate of advance of the tool carriage. Increase of this rate of feed resulted in increased unevenness of wear pattern along the carbide edge. The relationship between wear and area traversed was approximately linear under given conditions, and these were standardised for the main series of tests using side cuts as follows :—

Rotation rate = 32 rev./min.
Depth of cut = 0·020 in. (lathe setting)
Total length of cut = 2·25 in.
Feed per revolution = 0·0138 in. (lathe setting)

and a sufficient number of cuts was taken for a reasonable weight loss. For the end cuts the same rotation rate was used, and the total depth of cut was usually 0·5 in., with a set feed of 0·0037 in./rev. Fig. 5 shows the arrangement for this test. Some tests were also carried out at different speeds and feeds. *(to be continued)*


REFERENCES

1 Rautala, P. and Norton, J. T., *J. of Metals*, 1952, **4**, (10), 1045 *et seq.*
2 Sandford, E. J., and Trent, E. M., "Symposium on Powder Metallurgy, 1947." Iron & Steel Institute, Special Report No. 38.
3 Smith, G. S., *The Engineer*, 1949, **188**, (4883), 235. Also Thibault, H. W., and Nyquist, H. L., *Trans. Am. Soc. Metals*, 1947, **38**, 271.
4 Nowotny, H. and Vitovec, F., "Plansee Seminar, 1953," Ed. F. Benesovsky, Reutte/Tirol, Metallwerk Plansee.
5 Gardner, A. G., *Metallurgia*, 1953, **47**, (282), 163 *et seq.*
6 Muller, O., *Glückauf*, 1958, **94**, 1259.
7 Dawihl, W., and Hinnuber, *J. Kolloid-Zeitschrift*, 1943, **104**, (2/3), 233 *et seq.*
8 Redmond, J. C., "Machinery Theory and Practice." Handbook No. 5 Am. Soc. Metals, 1950.
9 Gurland, J. and Norton, J. T., *J. of Metals*, 1952, **4**, (10).
10 Gurland, J., and Bardzil, P., *Trans. A.I.M.E.*, 1955, **203**, 311 ; Gurland, J., and Norton, J. T., "Plansee Proceedings, 1956," Ed. F. Benesovsky, London, Pergammon Press, 99 *et seq.*
11 Lardner, E. and McGregor, N. B., *J. Inst. Metals*, 1951-52, **80**, 369 *et seq.*
12 Brownlee, L. D., Edwards, R., and Raine, T., "Symposium on Powder Metallurgy, 1954," Iron and Steel Institute, Group IV, 50 *et seq.*
13 "A.S.T.M. Standards, 1952. Part 2—Non-Ferrous." Specification No. B.276-52T.
14 Stevens, A. D., and Redmond, J. C., A.S.T.M. Special Technical Publication No. 140, 43 *et seq.*
15 Koster, W., and Rauscher, W., *Zeitschrift fur Metallkunde*, 1948, **39**, 111 *et seq.*
16 Odenhausen, H. Hartmetall im Bergbau. *Glückauf*, 1954, **90**, (1·2), 35 *et seq.*
17 Dawihl, W., "A Handbook of Hard Metals," London, 1955, H.M.S.O., 85 (Trans.).
18 Engle, E. W., "Powder Metallurgy" Ed. J. Wulff, Am. Soc. Metals, 1942, 436.
19 Miller, H. H., *Metal Progresses*, April, 1933, 75 *et seq.*
20 Haworth, R. D., Abrasion Resistance of Metals. *Transactions Am. Soc. Metals*, 1949, **41**, 819 *et seq.*
21 Industrial Diamond Information Bureau, List No. 103 (Micro-Abrasion Tester) and List No. 104 (Drum Abrasion Tester).
22 Schwarzkopf, P., and Kieffer, R., "Cemented Carbides," 1960. New York, Macmillan, 238-241.
23 Merchant, M. E., "Machinery Theory and Practice," Handbook No. 5, *Am. Soc. Metals*, 1950.
24 Batten, C., Thomas, D. G. A., and Wainwright, T., *Coll. Eng.*, Jan 1954, **31**, 21-25.
25 Penrice, T. W., and Shute, D. H., "Symposium on Powder Metallurgy, 1956," Iron and Steel Institute, Special Report No. 58, 277.
26 Schwarzkopf, P., and Kieffer, R., "Cemented Carbides," 1960. New York, Macmillan, 250 *et seq.*


## New Engineering and Building Centre for Birmingham

A NEW "shop window" for Britain's engineering and building trades is to be opened on one of the most important sites in Birmingham early next year. The £200,000 former Masonic Temple, in the heart of the city's civic and commercial community—Broad Street—is now being converted into a unique and comprehensive exhibition hall. Majestic rooms are being re-styled, entrances and staircases are being remodelled in a £80,000 alteration scheme which will turn the Temple into a centenary-year new headquarters for the Engineering and Building Centre, Birmingham. The new centre is, in fact, a direct descendant from the city's Iron and Coal Exchange which was founded in 1861 and flourished for eighty years. Its place was ultimately taken by the Birmingham Exchange and Engineering Centre in Stephenson Place, which is to remove and link with the building trade on the new project.

In a setting of modern planning and décor—from the panoramic effect created by an entirely new method of stand layout, to the rear extension on stilts—some of the country's finest products will be on show in a permanent, yet ever-changing, exhibition of interest to the technically minded, to those responsible for specifying products and materials and to the housewife. Almost everything from door knobs and bath taps, to tool steels and turbines will be on show in the 37,000 sq. ft. building which will also provide facilities for special short-term exhibitions in two smaller halls. In addition, there will be reading, writing and refreshment rooms, secretarial services, private lockers for exhibitors, lecture halls, projection equipment, a catalogue library and a full information service for visitors to discuss, without any obligation, any aspect of business from finding work contracts to locating the manufacturer of specific items.

The value of a centre of this kind to the country as a whole is inestimable. More than 10,000 inquiries a year are being handled at the Stephenson Place premises and in excess of 4,000 serious enquiries have been received at recent overseas Trade Fairs in which the Centre has organised group displays. Exhibitors are being invited to book space in the new centre, which has provision for about six hundred displays, and leaflets are being sent to firms in all parts of the country informing them of the style of things to come and emphasising that this is a British "show" and not only confined to the Midlands.

## New Efco Vacuum Furnace Division

As from the 1st November, the vacuum furnace activities of Efco Furnaces, Ltd., are being handled by a new division with offices, design and manufacturing facilities at Sheerwater, near Woking in Surrey. Mr. M. J. Severs, formerly with the furnace department of The General Electric Co., Ltd., has been appointed technical manager of the new division and Mr. W. Kuyser, previously vacuum sales manager of General Engineering Co. (Radcliffe), Ltd., has been appointed sales manager.

## Correction

BRITTLE FRACTURE : DESCRIPTIVE BIBLIOGRAPHY

In the article "Brittle Fracture : Descriptive Bibliography," which appeared in our September issue, reference was made to an article by Dr. J. M. Capus. The word 'Lead' in the abstract of this article should have read 'Phosphorous.' The bibliographer regrets this error.

# The Measurement of the Depth of a Carburised Case

By C. Dawes, A.I.M.

*Joseph Lucas Group Research Centre*

*There are several ways of measuring the case depth of a carburised steel component, the results varying according to the method adopted. Recent work has shown that a correlation exists between the etched case depth determined visually and the actual depth to a specified hardness level.*

THE term "case depth" is used as if it were a clearly delineated dimension, but in practise it is not well defined. Some metallurgists talk about case depth as being the "total penetration," whereas others use the term "effective case"; this latter in turn can be interpreted and measured in several ways. Usually the measurement is made by etching a section cut from an appropriate specimen, but often a quenched and fractured specimen is used. The engineer usually says that he is interested only in the depth to which 90% of the minimum surface hardness prevails.

The most precise method of measurement is to determine the hardness gradient of a test bar and ascertain the depth to some specific hardness level. This is a costly procedure and too time-consuming for purposes of production control. However, during recent work on carburising, the measurement of case depth on etched sections of quenched test pieces showed that a correlation exists between the etched case depth determined visually and the actual depth to a specified hardness level.

**Fig. 1.—Carburised mild steel (En 32) direct quenched: etched. × 100**

## Measuring Techniques

The tests were carried out on specimens of En 32, En 33 and En 39B steels which were carburised for 2, 6 and 15 hour cycles at 900° C., this being followed by slow cooling or direct quenching. A section was then cut through each specimen at right angles to the case and examined by the following methods:—

(1) Each section was etched in a picric-nitric acid solution until a good contrast was judged visually between the case and core, the total depth of the dark etching zone (Fig. 1) being measured, using a low powered Brinell microscope.

(2) With the quenched specimens, a hardness gradient was determined across the case using a micro-hardness tester.

(3) With En 39B, the etched depth was also measured after an isothermal treatment[1] which has been found to give a clearer demarcation between the carburised case and core (Fig. 2*a* and *b*). Details of this treatment are as follows:—

(*a*) The carburised specimens were heated to 750° C., held at this temperature for 30 minutes, and then removed from the furnace and air cooled.

(*b*) The test specimens were then packed in charcoal in boxes, heated to 750° C., held at this temperature for 30 minutes, transferred to a furnace at 580° C. and held at this temperature for four hours. The boxes were allowed to cool in air.

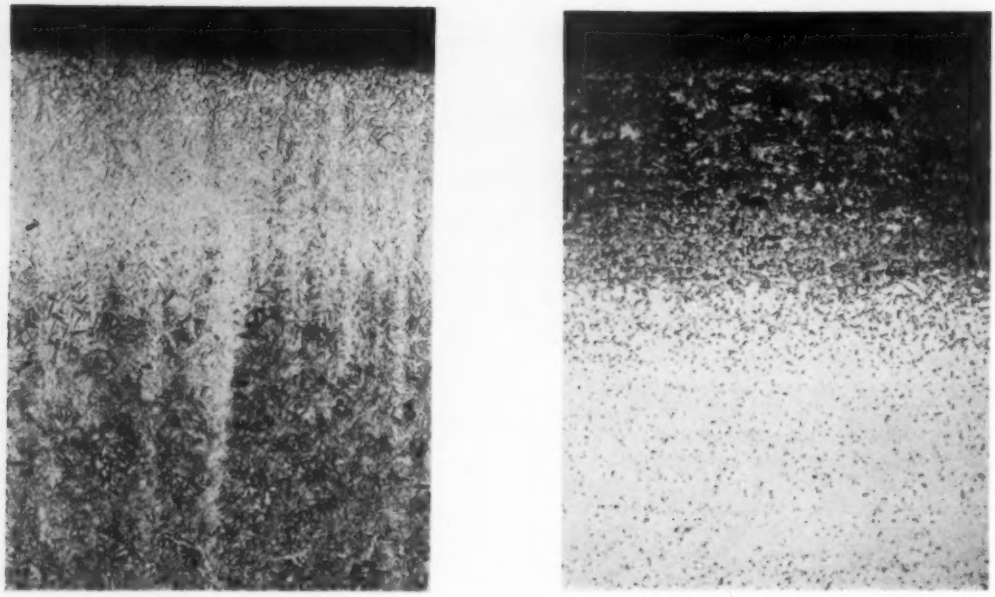
A study of the results of these experiments showed that:—

(1) The etched depth on slowly-cooled specimens bears no relationship to the "total penetration" or to any specific hardness level.

(2) With En 39B test pieces the etched case depth is the same whether the specimens are quenched or isothermally treated. However, the isothermally treated specimens have the clearer demarcation line.

(3) With quenched test pieces, as shown in Fig. 3, the total carbon penetration and hardness gradient of the carburised case for individual steels is reasonably similar for all carburising cycles, but the

1 Dawes C., "Case Depth Measurement of Carburised High Alloy Steels," *The Wild Barfield Heat Treatment Journal*, Dec. 1957, **VI** (45).



(a) (b)

**Fig. 2.—Carburised En 39 B steel : (a) direct quenched ; (b) isothermally transformed. Etched. × 100**

etched depth is very different ; for example, after a 6 hour carburising cycle the " total penetration " for all steels is 0·050 in., whereas the etched or " apparent " depth is :—

(*a*) For En 32—0·045 in.

(*b*) For En 33—0·037 in.

(*c*) For En 39B—0·035 in.

In each instance it will be noted, however, that the etched contrast line between the case and core for each individual steel corresponds to a specific hardness level, and is approximately 200 H.V. above core hardness, irrespective of case depth :—

(*a*) En 32—demarcation hardness 400 H.V., core hardness 200 H.V.

(*b*) En 33—demarcation hardness 550 H.V., core hardness 350 H.V.

(*c*) En 39B—demarcation hardness 600 H.V., core hardness 400 H.V.

From these results it is evident that the measurement of the dark case produced by etching a cross section of a *quenched test piece* could be an accepted method if an arbitrary demarcation of 200 H.V. above core hardness were fixed as the demarcation between case and core. However, if individual engineers and metallurgists persist in using their own interpretations of case depth, then it is necessary to have a system whereby a correlation can be made between one case depth determination and another.

## Correlation

Since the hardness gradient of the carburised case for individual steels is identical for each carburising cycle, a

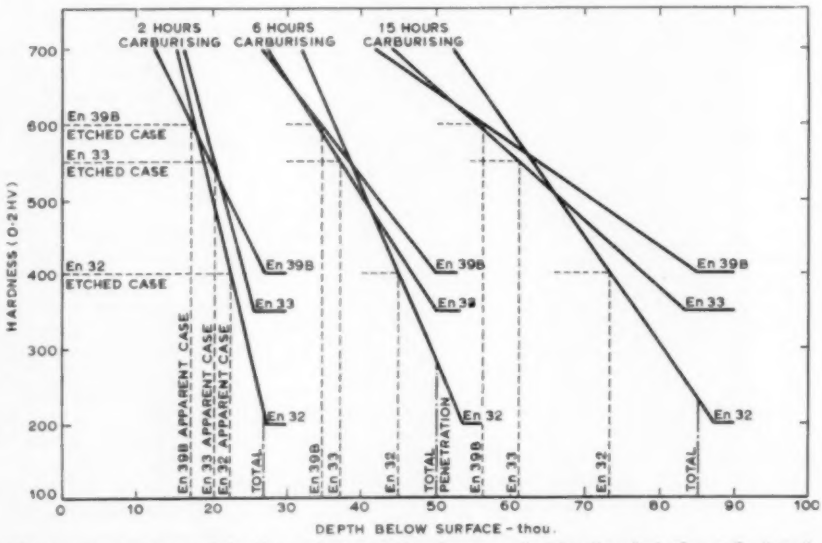



**Fig. 3.—Average straight line relation of hardness v. depth, showing the etched and total case depth.**

useful method of correlation would be to plot case depths to specific hardness levels against time, as shown in Fig. 4, and then to superimpose onto the graph the "apparent" or etched case depth for each individual steel. The case depth to any hardness level or the "total penetration" may then be determined simply from the etched case depth. For example, suppose a depth of 0·020 in. to a hardness value of 750 H.V. is needed in a mild steel component. By referring to Fig. 4, it will be seen that a horizontal line taken from the point of intersection of 750 H.V. and 0·020 in. crosses the etched case depth line for En 32 at 0·039 in. Thus, this "apparent" case depth of 0·039 in. must be obtained in the test piece to give the case depth specified. Similarly, if a case depth of 0·020 in. "total penetration" is required in a mild steel component, then the "apparent" or etched case depth would be 0·017 in.

This system of correlation could be used when considering the carburising of high alloy steels, whose "apparent" case depth (unless a long conditioning treatment is given, i.e. isothermal annealing) is difficult to determine. For example, since carburised En 33 gives a more defined contrast between the case and core than does En 39B, an En 33 test piece could be carburised with a batch of En 39B components. Thus, if a case depth of 750 H.V. to 0·020 in. is required in an En 39B component, the "apparent" case depth necessary to meet this requirement would be :—

(*a*) With an En 33 test piece—0·033 in., or

(*b*) With an En 32 test piece—0·039 in.

**Acknowledgment**

The author is indebted to Messrs. Joseph Lucas, Ltd., for permission to publish this paper.

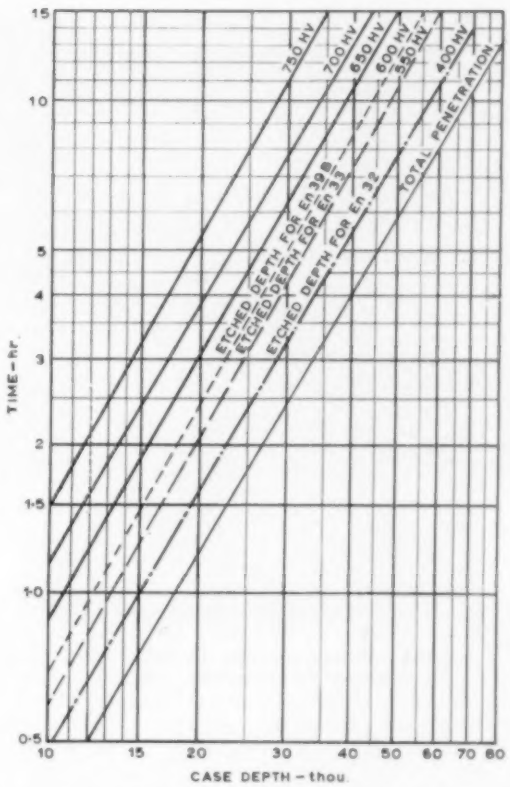



**Fig. 4.—Apparent and specified case depths of mild and alloy steels.**

## Hydrostatic Extrusion

A NEW method of extrusion developed by the D.S.I.R.'s National Engineering Laboratory gives products with more uniform mechanical properties and requires much lower pressures than the conventional process. Extrusion pressure is applied hydrostatically without any direct contact between ram and billet. Tests of the process have so far been restricted to pure aluminium alloy, but the laboratory is taking the work a stage further by investigating the cold extrusion of other metals, especially steels.

In the new process a cone is machined at one end of the billet so that it fits closely into a die with a conical entry. The die forms the exit from a cylindrical high-pressure chamber containing a liquid, such as glycerine, castor oil, or a dispersion of molybdenum disulphide in oil. The other end of the chamber is closed by the ram of a hydraulic press. As the ram moves into the chamber, pressure builds up in the liquid, which transmits the extrusion pressure to the billet. The material is extruded through the die without any direct contact between ram and billet. The fluid acts as an efficient lubricant and makes it possible to use conical-entry dies with very small die angles.

In addition, the nosing of the billet reduces the amount of work expended in deforming the metal and hence the maximum extrusion pressure required. Reductions in extrusion pressure of 30–40% have been obtained in the laboratory tests. With pure aluminium, the maximum extrusion pressure for the production of rod at an extrusion ratio of 7, through a conical-entry die, with a 20° included angle, was 17 tons/sq. in., compared with a pressure of 32 tons/sq. in., for a conventional extrusion through a square-entry die. With the alloy (0·7% magnesium, 1% silicon and 0·7% manganese), the pressure was 29 tons/sq. in., compared with 43 tons/sq. in. by conventional methods. All these figures are extrusion from an unheated billet. The distribution of hardness over the cross-section of the extruded rod was much more uniform than usual, and this will often be an important advantage. These results suggest that cold extrusion of high strength materials will be possible.

## R.C.I. Marketing Sonatest Equipment

AN agreement has been signed between Research and Control Instruments, Ltd., of Kings Cross, London, W.C.1, and Sonatest, Ltd., of London, W.C.1, to the effect that marketing in the United Kingdom of Sonatest ultrasonic non-destructive testing equipment will be carried out exclusively by Research and Control Instruments, Ltd. With the addition of Sonatest's equipment, technical knowledge and experience of ultrasonic flaw-detection, R.C.I.'s scope now extends over a wide range of applications for non-destructive testing.

A selection of special shapes produced by the Kingscliffe process.

# Making Refractory Insulating Bricks and Special Shapes

## Kingscliffe Development Eliminates "Combustible" from Mix

DETAILS of a completely new process for the manufacture of refractory insulating bricks and special shapes—known as the "23" range—have been released by Thos. Marshall & Co. (Loxley), Ltd., Sheffield, parent company of Kingscliffe Insulating Products, Ltd., Wrexham, and head of the Marshall Refractories group of companies. The Kingscliffe method (patents pending) makes a complete break with the traditional process in which a mixture of clay and combustible is kilned in order to produce an oversize, often heat-distorted block from which the finished brick has to be machined. By using the Kingscliffe method, the need for a combustible is entirely eliminated, and the as-kilned product is true to shape and ready for despatch. Production rate is twice that of the traditional system.

Over many years Kingscliffe Insulating Products, Ltd.—K.I.P.—have been the sole producers in the U.K. of the very low density high temperature insulating firebrick, which has played an important part in the development of the modern heat treatment furnace, particularly batch furnaces, where fuel economy is closely linked with low thermal storage capacity of the furnace. These bricks have a service temperature of 1,100° C. (2,000° F.) and are available in two densities—26 and 36 lb./cu. ft.

The basic material for their manufacture is a micaceous mineral, vermiculite ore, which is first exfoliated in an oil-fired furnace and then mixed with a special bond clay and formed into slabs or moulded into shapes. The slabs and shapes are chamber dried and kilned in intermittent kilns, after which the slabs can be cut into bricks or machined to specific shapes.

These lightweight bricks and shapes are ideal for use as hot-face internal linings of industrial gas and electric heat treatment furnaces, in removable cover furnaces, in large stress-relieving furnaces, as domestic gas fire backs, and as an insulating backing behind the hot face in kilns. Their excellent electrical insulating properties make them particularly suitable for use in electric furnaces, and having a high resistance to carbon monoxide attack they are extensively used for lining carburising and malleablising furnaces.

Vermiculite bricks, whilst possessing many excellent qualities, are limited in application by their maximum service temperature of 1,100° C. (2,000° F.). The need for bricks suitable for higher operating temperatures is met in the Kingscliffe range by K.I.P.23, K.I.P.26 and K.I.P.28, with maximum service temperatures of 1,260° C. (2,300° F.), 1,430° C. (2,600° F.) and 1,540° C. (2,800° F.). The last two are made by conventional methods, mixing a combustible material with fireclay,

Glowing hot aggregated fireclay falling from the furnace (right) cools off on the slowly moving conveyor.

moulding or pressing to shape, and then firing to produce a porous body. The new K.I.P.23 is the result of intensive research into the properties and behaviour of fireclays at elevated temperatures and the development of an entirely new method of production. The new process allows a high degree of control to be exercised over the size of pores, and enables standard straights to be produced without machining. Furthermore, exhaustive testing has shown that the spread of values in all properties is considerably less than occurs in traditional methods of manufacture.

### The Process Described

In the course of the study of the behaviour of fireclays at high temperature, it was discovered that under certain conditions finely divided clays could be agglomerated to produce a lightweight aggregate, and on this discovery the new manufacturing process for the " 23 " range of bricks is based.

**One of the M.I.A. automatic brick-makers, showing four newly-pressed " 23 " bricks.**

In the first stage of the new process, rough ground fireclay from Marshall's deposits at Loxley is fed into an attritor and finely pulverised. The pulverised clay, containing about 8% carbon, is then blown into two specially designed vertical shaft furnaces and fired at 1,300° C. Each furnace is fired by four oil burners, and has a production capacity of 1,200 lb./hr. The air/clay jets feeding the furnace with pulverised fireclay are set tangentially to the furnace walls, which results in a spinning action being imparted to the hot gases and clay, causing the clay particles to agglomerate on the walls of the furnace. The furnace temperature is such that the agglomerate is transformed into pyro-plastic masses which break away from the walls, drop to the furnace hearth and fall out on to a steel slat and chain conveyor. Cyclone grit arrestors extract the ultra-fine particles from the exhaust gases. The furnaces are lined with top quality insulating firebrick, which has good pick-up properties : at the top, where the pulverised fireclay is blown-in, zircon refractories are used.

**Hand-filling a " special " mould : shapes produced in this mould are shown in left foreground.**

The product on the conveyor is advanced slowly so that it has time to cool before being automatically fed into a wire mesh roll crusher. The reduced product of the roll crusher is next elevated and graded through screens into coarse ($\frac{3}{16}$ in., about 10% of the special product), medium ($\frac{1}{8}$ in., 20%), and fine (24 mesh, 70%), after which it is gravity fed into appropriate storage hoppers.

A hopper scale batch-weighs from the three hoppers, and a proportion of finely-ground ball clay is added from a fourth hopper. The resulting mass is first mixed in its dry state and then with a special solution, after which the batch is ready for forming on the two automatic brick-making machines built specially for this purpose by Modern Industrial Appliances, Ltd., a Sheffield member of the Marshall Refractories group. The bottom of the mould is lined with a loose metal plate on which the requisite volume of mixture is fed and pressed to size. The plate is necessary because the bricks are not strong enough to handle in the as-pressed condition. After tunnel drying for about 28 hours they can be handled and the plates removed. The final production stage is the tunnel-kilning operation, which takes a further 36 hours. The bricks emerging from the tunnel kiln are correct to size and can be palletised immediately ready for despatch.

### Special Shapes

The new process is particularly suitable for the production of special shapes since expensive machining is eliminated. Furthermore, traditional methods of manufacture, in the case of large special shapes, require

a long firing period to ensure that all combustible and combined carbon is removed before reaching soaking temperature. Nevertheless, "black heart" is not uncommon in large shapes.

Special shapes of high spall-resistance (K.I.P.23 H.S.R.) are produced in moulds devised and produced by Kingscliffe. Only the coarse and medium fractions of the screened agglomerate are used in this case, and the moulds are hand-filled with a weighed amount of this high spall-resistance mix, subsequently being compacted on a Modern Industrial Appliance cam-ram machine.

The K.I.P.23 H.S.R. special shapes have a resistance to thermal shock greatly exceeding that for conventional insulating refractories, and they are particularly suitable for suspended roof blocks, furnace door linings, and bogie hearth and tunnel kiln car construction.

# Conditions in Steel Foundries

## Better "Housekeeping" Urged by Factory Inspectorate Report

A HIGHER standard of "good housekeeping" in steel foundries in Great Britain to deal with the elimination of dust and to bring about a substantial reduction in accidents, is urged by the Joint Standing Committee on Conditions in Steel Foundries, whose first report to Mr. T. W. McCullough, O.B.E., Chief Inspector of Factories, has recently been published*.

The committee was set up in 1952 "to keep under review conditions and developments in the industry affecting the health, safety and welfare of persons employed." It continued the work of the Committee on Dust in Steel Foundries, which was appointed in 1943, and which reported twice, in 1944 and 1951, indicating on the latter occasion that there were still many problems to be solved.

"Our task," the committee state, "is by no means ended, but we think we should give you a report of the last seven years' work, even though many of the research and development projects were published as they were completed. We think it desirable that the results of the work that has been should have the widest possible publicity, and, more important still, should be put into practice in the industry at once."

Most of the report, which is illustrated, is devoted to the prevention of industrial diseases in steel foundries by the elimination, suppression or control of dust and fumes, but the equally important problem of accident prevention has not been neglected. Included in the documents are thirty appendices, which summarise much of the original work that has been done in an effort to solve individual problems.

### Standards of Ventilation

Dealing with the elimination and control of dust the committee urge a high standard of ventilation, and suggest that, where possible, dusty work should be segregated in time, for example by working at night, so that the dust would be produced when the smallest number of men would be in the foundry to breathe it. Emphasis is also placed on the real need for "good housekeeping" in steel foundries.

"Many foundries," they state, "still need a much higher standard, and we are convinced that even the best foundries cannot afford to ignore this aspect of the matter. This involves everybody in the foundry, demanding the most whole-hearted co-operation of management and men."

Considerable time and energy was devoted by the committee to the examination and development of suitable methods of dust control for the varying circumstances of the industry. Existing methods, such as the use of vacuum cleaners, water, blasting techniques and local exhaust ventilation are discussed, and the committee also summarise the large amount of work that has been done on so many aspects of protection against dust since 1951.

"We have no doubt," they add, "that further work, and more experience may well produce different methods, but we have no doubt either that suitable protective methods should be selected from the variety which is now available, and applied by every foundry at once because dressers should not work the tools without the protection that is now available." Apart from the legal obligations under the Iron and Steel Foundries Regulations, 1953, the committee say they look for a "sense of responsibility which will ensure that these new devices will be installed and worked to the highest possible standard by men and management together."

### Lines of Action

From their examination of the industry's accident statistics during the period 1953–1956 the committee come to the conclusion that "the yearly totals could be very substantially reduced by a determined attack on the principal causation groups," and they recommend the following most promising lines of action :—

(1) A higher standard of housekeeping, especially about the provision and maintenance of better floors and gangways, with particular attention to obstructions, permanent and temporary, on such floors and gangways.
(2) Wider provision of suitable protective clothing and other protective devices.
(3) The proper care and use of such equipment by workpeople.
(4) Early first aid treatment for all injuries.
(5) Better instruction in safe methods and practices in manual weight lifting, and also in the handling of loads by cranes and other hoisting appliances.

### Essential Principles

For such a campaign to be successful two essential principles are laid down—keen interest and determination to succeed by the management, and equally keen interest and fullest co-operation by the workers. Such co-operation could often best be achieved by a Safety Committee, on which men and management were equally and fully represented. While many firms already have such committees, the committee are of the opinion that there is much new ground to be broken and that some of the existing committees could possibly do with rejuvenating.

* H.M. Stationery Office, or through any bookseller, price 10s. 0d. net.

# The Early History of Zinc

By J. R. Partington, M.B.E., D.Sc.

*One of the most difficult, obscure and incomplete chapters in the history of early metallurgy is concerned with the metal zinc. Even recent publications are defective and often inaccurate and the following brief notes correct many of the statements they contain.*

AN analysed specimen of Predynastic Egyptian brass contained 1·55% of zinc and 0·38% of tin. There seem to be no early specimens of Mesopotamian brass, although it is thought that the name occurs in Sumerian and Akkadian and that *tusku* is a name for zinc oxide or carbonate, later called *tutia*. Brass from Palestine of 1400–1000 B.C. contains 23% of zinc, and the connection with Cyprus by way of Rās Shamra suggests that the important brass industry in Cyprus in the Roman period may have come from further East.

In Cyprus, the zinc ore calamine (zinc carbonate) was smelted with copper in a furnace of the same type as that used in Germany in the seventeenth century. Zinc oxide, called *pompholyx* or *spodos*, was obtained as a by-product. The process was kept secret. Galen, who visited the smeltery, was given specimens but did not get a sight of the working of the furnaces for brass.

The Greek name for brass, *oreichalkos* (literally "mountain copper") occurs in Hesiod (650–600 B.C.), a pseudo-Homeric hymn (*c.* 500 B.C.), and Plato (*c.* 350 B.C.). Plato used it for a flame-coloured metal "dug out of the earth" (as in the Bible, Job says "out of the hills thou mayest dig brass"), but in his time, he says, it was only a name. The best Roman authors use the Greek name *orichalcum*; others use *aurichalcum*, i.e. "golden copper." The pseudo-Aristotelian *De Mirabilibus* mentions brass as a Persian or Indian metal, made from copper and an "earth," no doubt a zinc ore.

The Romans were thoroughly familiar with brass, by way of Cyprus. There are many analysed specimens of Roman brass, although it is not long since brass was said to be unknown in antiquity. The Romans established the brass industry at Cologne about the beginning of the Christian era, and made brass known to the rest of Europe.

The first definite literary mention of the metal zinc itself seems to be in Strabo (*c.* 7 A.D.). The passage is very obscure and is almost certainly corrupt, but with slight emendation it reads literally: "There is an ore found at Andeira which when roasted produces an ash. When this is put into a furnace with coal it goes away as mock-silver, which when added to copper forms the alloy called brass." Brass was well-known at the time and "mock-silver" must have been zinc, since nothing but this when added to copper could form brass. The Greek silver mines at Laureion contain an abundance of zinc ore (calamine, zinc carbonate) which has been worked in recent times.

## Specimens of Early Zinc

At least seven early European specimens of metallic zinc, mostly analysed or otherwise characterised, are reported from widely-separated sites. There are hollow silver bracelets filled with zinc (recalling Strabo's "mock-silver") from Kamiros on the island of Rhodes of about 500 B.C.; a plate of nearly pure zinc from Athens of about 250 B.C.; a large bar of zinc found in the ruins of a Roman villa in Champagne; an idol of over 80% of zinc found in a Dacian hoard of the first century A.D. at Tordosch (Siebenbürgen); a piece of zinc found in a Roman house in Bulgaria; zinc plates from Bosnia; and the pediment of a fountain at Pompeii (which has since disappeared). There can be no doubt, therefore, that zinc as such was known to the Greeks and Romans, but we have no clear information as to how they obtained it. The words "goes away" in Strabo suggest some kind of distillation or sublimation process.

The early history of distillation is another subject badly in need of overhauling. There are grounds for thinking that distillation and sublimation were early practised in Mesopotamia, and they were certainly known in Egypt in the early centuries of the Christian era. To make metallic zinc by sublimation merely requires a fairly cool lid on a crucible, and a primitive form of distillation "by descension," which long continued to be used in the metallurgy of zinc, is a simple process. The condensation of molten zinc from the vapour is difficult and unless air is excluded a dust of zinc and zinc oxide is obtained. In the earlier process used in England a mixture of zinc ore and charcoal was heated in a crucible through the bottom of which an iron tube passed down into a condenser in which the zinc vapour formed liquid zinc.

Metallic zinc was probably first obtained accidentally and in small quantities by the condensation of its vapour on cooler parts of the brass furnaces in Cyprus and the silver furnaces at Laureion. It was formed in the same way in the brass furnaces at Rammelsberg and Goslar in the seventeenth century. Some of the metal volatilised and collected on the cool walls of the furnace. It was extracted and sold as a curiosity by the workmen. This process is fully described from personal observation by Stahl and by Neumann in the eighteenth century, and is given in an English book published in 1743.

## Eastern Origins

It is possible that a knowledge of brass came to the West from Persia. Marco Polo (*d.* 1324) saw zinc oxide (called *tutia*) being made in brass furnaces at Kobinam, between Yezd and Kirman. It was made by roasting the ore in a furnace with an iron grating on which the fine smoke of the tutia (or totie) settled. Marco Polo seems to mention metallic zinc as "pewter," as made in Central India and an import into Cambodia in Indo-China. It is possible that the production of zinc began in Persia from knowledge which had come from Cyprus or further east, but at present nothing definite can be said on this.

Arabic authors from the time of Jābir ibn Hayyān (*c.* 720–813 A.D.) mention a "Chinese stone" (Khār Sīnī or in Persian Khār Chīnī) which al-Khwārizmi

(*c.* 950 A.D.) calls "Chinese iron." Jābir's monograph on zinc is lost but an extract from it is given by al-Dimashqī (1265–1326). He says Khār Sīnī is a white metal like tin, but with a duller sound and more changeable, losing its colour and hardness. It comes from China and is found only there, where it is taken from mines like other minerals. Chinese mirrors and bells are made from it. It is the "spirit of tutia" (which indicates that it was volatile and probably obtained by distillation). Al-Rāzī (*d.* 925 A.D.) says "its mine is in the land of China." The accounts of zinc in later Arabic and Persian works become more and more confused, and apparently the metal was little known. They all say it formed various kinds of brass.

Metallic zinc is said to be mentioned in the Sanskrit works *Arthashastra*, *Sushruta*, and *Charaka*. These are old but in their present forms contain interpolations which are probably not later than the sixth century. The preparation of zinc by distillation processes is briefly described in the *Rasaratnākara* attributed to Nāgārjuna (7th–8th cent. A.D.), the *Rasārnarva* (*c.* 1150–1200) and the *Rasaratnasamuccaya* (*c.* 1350 or earlier), the last containing pictures of the apparatus which leave no doubt of the method used. The *Rasārnarva* mentions a koshṭī apparatus for extracting the "essence of metals" and says that *rasaka* (zinc ore, calamine) when mixed with borax and various organic materials (which yield carbon on heating) and heated in the koshṭī apparatus yields an "essence of the appearance of tin." Tin is not volatile, and this, with the mention of the zinc ore, shows that this was zinc.

The *Rasaratnasamuccaya* specifies mixing the zinc ore with soot, borax, and various vegetable materials in a crucible with a tubulure, covered with another crucible. The various vegetable materials in the recipes are characteristically Indian. The translation is defective and probably the *adhaspātana* apparatus shown in figures was used, in which the zinc distils from an upper into a lower crucible. The koshṭī apparatus is a crucible containing the material inverted over a vessel of water. On heating the upper crucible, "the essence drops into the water."

A description of the old method which he saw used in India in 1850 by Brooke is not very clear, but it seems to have involved distillation. A Sanskrit dictionary of 1374 calls zinc *jashada*, but this is the Persian *jast* which Abu-'l Fazl (1595) says was the "spirit of tutia" (i.e. a volatile metal obtained from zinc oxide).

Brass is said to be mentioned as a Persian metal in Chinese works of the seventh century. What is translated zinc is said in a Chinese work of 1225 to be imported from Ki Shih, an island in the Persian Gulf. The first Chinese description of the preparation of zinc (*ya yuen*) is in a work of 1637, the *T'ien Kung K'ai Wu*, and is very confused. It says the ore calamine (described in earlier works) is finely powdered and compressed into crucibles. The crucibles are stacked in a heap with coal and the fire lighted. When the fire has gone out a ball of *ya yuen* is taken out of the crucible. It combines with copper and in a fire it forms an inflammable vapour. If coal were mixed with the ore in the crucible (a detail which is omitted) the process would be the crude one described by Strabo. Zinc in China had no special name, being called "lead" and it is still called "Japanese lead."

The work of 1637 and a Japanese encyclopaedia of 1713, the *Wakan sanzai zue* (which was unable to give the method of preparation), say that zinc was not known in China or Japan before about 1600. The Chinese method of extraction described imperfectly by Staunton in 1797 involved heating a mixture of calamine and charcoal in an earthen pot and condensation of the vapour in water.

### Zinc in Europe

Zinc was imported into Europe from the Far East from about 1600 by the Portuguese (who called it *tutenague*) and Dutch (who called it *calaëm* or *calin*, which is properly the name of tin). It was known in Europe as *spiautre*, *speautre*, *spelter*, *and pewter*. Libavius in some letters in 1611 and 1616 says it came from the East Indies and he thought it was a mixture of mercury and silver. Accounts by travellers in the East never make it quite clear whether the metal came from India or China. A specimen in a ship which was carrying goods from the Far East and was wrecked in 1745 was found to contain 99% of zinc. Even as late as 1808 de Guignes thought *tutenague* was an alloy of iron and lead, with perhaps some bismuth; Anquetil du Perron (1771) thought it was an alloy of iron and tin. In Europe zinc was classed as a semi-metal.

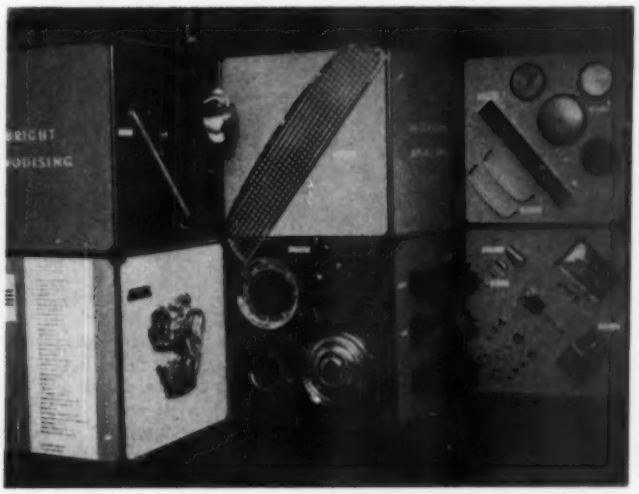
The earliest European production of zinc was established in England near Bristol (where zinc is still made). Large quantities of zinc made there from calamine were exported in 1685 to Sweden for the manufacture of brass, and Boyle in 1684 describes it as spelter, which is still the trade name. This is much earlier than the traditional beginning of the zinc industry in Bristol in 1743 after experiments by Isaac Lawson in 1730. In the reign of Louis XIV many experiments were made in Paris, perhaps by Nicolas de Locques, but were not published. The earliest German description, by Löhneyss in 1690, says "zinck" (which he confuses with bismuth) was made in very small quantities as a curiosity at Goslar.

Many parts of the history of zinc are still very obscure and the subject needs complete re-examination. At least it can be said that the current accounts of it are very defective, since they are mostly copied from works published in the eighteenth century.

## Die Casting Discussion Group

Following the outstanding success of the technical discussion meetings on die casting practice and techniques arranged by the Zinc Alloy Die Casters' Association last winter, the first of this season's meetings was held on Tuesday, 17th October, when about eighty engineers from sixteen member companies met in the fine new council room of the Birmingham Chamber of Commerce to discuss "metal melting and handling." As at previous meetings, Mr. Turner, of Metal Castings Doehler, Ltd., took the chair and successfully maintained a friendly, informal atmosphere. The subject was introduced by Mr. Newby, of the Birmingham Aluminium Casting (1903) Co., Ltd., who went on to talk about aluminium alloys, and Mr. Lodder, of the Imperial Smelting Corporation, Ltd., dealt with zinc alloys. The discussion centred largely on the technique of remelting aluminium alloy scrap and the maintenance of zinc alloy composition within specification. The next meeting in the series will be in London on Monday 20th November, and details may be obtained from the Zinc Alloy Die Casters' Association, 24 Berkeley Square, London W.1.

# Report on the Nottingham Conference on the Anodising of Aluminium and its Alloys



**Displays of bright anodising for car trim, reflectors and personal articles. Also shown are anodised finishes for manufactured consumer goods.**

ANODISING has come of age was the theme of this Conference, organised by the Aluminium Development Association in conjunction with the Department of Metallurgy, University of Nottingham. Four technical sessions were devoted to matters of primary interest to the user of anodising. Two further sessions were devoted to the theory of anodising and of related processes, and while these showed that a large amount of new information has recently become available, they also indicated vast fields of factual data still without satisfactory theoretical bases.

An exhibition enabled many of the recent developments in anodising, both in research tools and in industrial applications, to be displayed. The conference was residential, allowing maximum time for inspection of exhibits as well as for informal discussion.

At the Conference Dinner where the Vice-Chancellor of the University (MR. B. HALLWARD) welcomed the delegates, SIR GEOFFREY BOURNE (Director-General of the Aluminium Development Association) spoke of the need for close collaboration by all interested parties in the rapidly expanding development of anodised aluminium. PROFESSOR O'NEILL, replying on behalf of the guests, expressed mild surprise that an oxide film—a mere tarnish—could be of such industrial importance !

## Anodising from the Users' Viewpoint

*Current Trends in Materials for Anodising*, by PROFESSOR J.W. CUTHBERTSON (University of Nottingham) and MR. J. C. BAILEY (Aluminium Development Association);

*Control of Quality of Anodic Finishes*, by MR. J. G. SIMMONS (Acorn Anodising, Ltd.);

*The Properties and Performance of Anodic Films*, by MR. J. M. PERFECT (Anodising and Platings, Ltd.).

Cuthbertson and Bailey emphasise that anodising is an almost unique process of metal finishing, in that it involves controlled attack on the base metal, and consequently removes the original surface layers ; this attack results in conversion of metal to oxide. The quality and decorative value of the coating obtained, therefore, largely depends on the composition and structure of the aluminium. Many of the aluminium materials listed in B.S.1470–1477 have good anodising characteristics and yield a very satisfying appearance in their final anodised form, but for decorative anodising it is common practice of the Aluminium Industry to supply " anodising quality " aluminium which has been subjected to special fabricating techniques to avoid " banding " and other undesirable surface effects. At present, however, the degree of improvement offered by " anodising quality " is not standardised and may vary considerably.

The multiplicity of processes in producing the final anodised product make it essential for the co-ordination between metal supplier, fabricator, anodiser and user to be close, and to assist proper understanding of the various aspects Cuthbertson and Bailey tabulate some of the responsibilities of the various concerns involved.

As a revised British Standard 1615 " Anodic Oxidation Coatings on Aluminium " has just been issued (October 2nd), Simmons, in his paper, concentrates on aspects of the control of quality most directly related to anodising practice. He emphasises that visual inspection is the most practical proposition for finding surface defects and for colour matching. For film thickness, he quotes results which show that all the methods normally used—non-destructive eddy current tests, microsections, loss in weight or micrometer measurements—have their limitations but that, in practice, satisfactory results may be achieved by one or more of these methods coupled with the experienced anodiser's knowledge of appropriate anodising conditions for a given thickness. Simmons points out the limitations of other tests, noting for example that in outdoor service corrosion is often accompanied by abrasion, and that this is not reproduced in the usual accelerated tests. Nevertheless, these tests, notably the degree of sealing, the corrosion resistance, and the abrasion resistance, do provide the necessary quality control once the properties needed for a given application have been determined.

Perfect's paper lists the major properties of anodised aluminium, noting in particular the alloys which are most suitable for different forms of anodising. The

quantitative data available, however, is somewhat limited, because much of the published material either relates to anodic films of incompletely specified processing techniques, or else utilises test methods which are now regarded as inappropriate or inadequate. In preparing anodised aluminium for any particular use, it is indicated that the property most desired can be emphasised by the choice of appropriate processing conditions.

### Discussion

Mr. P. Smith (Acorn Anodising Co., Ltd.), opening the discussion, welcomed the increasing collaboration between the anodising and the aluminium industries, noting that in the past there had been too much *ad hoc* anodising development. It was necessary to establish a planned programme of basic research which could be jointly financed. Later speakers concurred with this view and it was mentioned that in two fields—creation of an atlas of defects and standardisation of surface finish designations—preliminary investigations were already in hand by a joint panel.

Controversy arose over the merits of integrated fabricating and anodising facilities or the use of specialist anodisers as outworkers. Mr. M. Adie (Anotints, Ltd.) emphasised the wide experience of the outwork anodiser whom he termed "the anodising specialist." Mr. P. Gardiner (Gardiner Sons and Co., Ltd.) noted the dangers of damage both during transport and also during fabrication in a works which was otherwise primarily concerned with mill-finished aluminium with which the occasional scratch was not so critical. The concensus of opinion appeared to be that major product lines required the installation of anodising equipment at the fabricator's works, but that there would always be a large tonnage of relatively small production runs which would be more economically processed by an outwork anodiser.

Mr. C. A. Morton (General Electric Co., Ltd.) and Mr. M. D. Pidgeon (Frederick Sage and Co., Ltd.) asked for greater guidance for the user in selection of material, in design and tolerances, and in fabrication. In this connection it is interesting to note that the B.S.I. is already considering the possibilities of a Code of Practice on anodising. The numerous test methods and instruments currently proposed for inspection of anodic coatings, was described as an economic nightmare by Mr. P. Smith: the newly proposed Ford Aluminium Corrosion Test apparatus, for example, cost more than $2,000. Both Mr. W. Campbell (Hard Aluminium Surfaces, Ltd.) and Mr. F. Sacchi (I.S.M.L., Italy) mentioned simple acid dissolution tests (for adequacy of sealing) but which had not yet been sufficiently widely used to determine their limitations. Further work on such topics was urgently needed.

## Bright Anodised Aluminium

*Bright Anodised Aluminium Surfaces*, by Dr. B. A. Scott and Mr. H. M. Bigford (British Aluminium Co. Ltd.);

*Colour and Texture in Anodic Finishes—Reflectivity Considerations*, by Dr. E. F. Barkman (Reynolds Metals Co., Ltd.).

Both these papers are concerned with the measurement of light reflected from polished metal surfaces and initially consider the definitions and concepts involved. Total reflectivity involves no ambiguity and can be readily measured instrumentally. This reflected light, however, is distributed over a wide range of angles of reflection and the distribution curve has a peak normally at an angle equal to the angle of incidence. The amount of light reflected at this peak position may be related both to the total amount of light reflected (a ratio related to Barkman's *specular reflectance factor*—a measure of image clarity), and also to the total amount of incident light (a ratio related to Barkman's *specular brightness factor*). These two ratios are indicative of the visual appearance of the bright surface. However in practical measurements of this peak (the specular reflection), it is necessary to include a finite solid angle around the theoretical position, and Scott and Bigford clearly point out how existing data from different sources have been contradictory because of differences in this angle of acceptance.

The guild meter, previously standardised for this purpose in B.S.1615, has a very wide angle of acceptance, and while this is of no disadvantage with surfaces of relatively low specular reflectivity, it gives insufficient distinction when comparing surfaces of high specular reflectivity, such as is the case with most bright anodised aluminium. The gloss head described by Scott and Bigford has a very narrow angle of acceptance, and gives useful distinctions even between surfaces of high reflectivity: it is the instrument included in the revised B.S.1615.

In comparing bright aluminium surfaces in any particular application it is usually adequate to measure only the specular reflectivity, as the total reflectivity is almost invariant for a given aluminium.

Barkman, in his paper, describes and utilises the Gardner modified pivotable-sphere haze meter, which would appear to have a slightly greater angle of acceptance than the gloss head instrument.

For practical purposes, the image clarity may be assessed visually, but for quantitative data the Gardam grid is used. A black mesh on white ground is reflected at 45° in the bright aluminium held by the inspector. The maximum distance between grid and sample for resolution of the reflection is recorded: this normally correlates with specular reflectivity and is independent of image contrast.

Both authors continue by giving reflectivity values for a range of alloys and specified anodising conditions while the causes of loss of brightness by deviation of reflected light, both within the anodic film and at the aluminium oxide/air interface, are discussed. Modification of anodising methods are suggested for reducing these losses for the various grades of aluminium.

Scott and Bigford then describe the increasing use of aluminium in bright trim, particularly car trim, and in later discussion it was noted that seventeen major British car radiator grille designs are now all in bright anodised aluminium.

### Discussion

Opening the discussion, Mr. W. G. L. Miller (Ford Motor Co., Ltd.) emphasised that aluminium had a finish in its own right and did not, and should not, need comparing with chromium plate. It could provide a very much more attractive, quieter, and more dignified finish than chromium plate and with a higher image clarity. Some discussion took place on the relative merits of anodised aluminium and chromium plated bright trim finishes in which almost all the evidence

**The control of quality of anodic films by tests was one of the more important topics of the conference. Delegates were able to experiment with instruments used for testing the thickness and reflectivity of films, such as the Solus-Schall Isometer, the Gardam grid and the gloss head apparatus shown here.**

**A number of Swiss scales, dials, etc., showing detail transferred to anodised surfaces. In the group is a photograph screen-printed on anodised aluminium.**

quoted was that of visual examination, and Mr. Miller made the point that we were still a long way from replacing the human eye by instrumentation in assessing the excellence of a bright trim finish.

Mr. J. English (British Aluminium Co., Ltd.) and Mr. A. dePrez (Richmonds Gas Stove Co., Ltd.) both commented on improvements in chromium plate over the last few years, but no cases were recorded in which chromium plate had replaced anodised aluminium.

Mr. Sprague (Consultant) questioned whether it was really true that mechanical polishing was not necessary in some cases. Dr. Scott remarked that further work on liquid polishing compositions and wet polishing techniques might yield advantageous results, and that mechanical polishing could, in all cases, improve the product.

It was queried whether a 7 micron film was adequate thickness for car trim when 25 microns or more was being advocated for architectural applications, but Dr. Scott pointed out that the former, with much more frequent cleaning, had to last perhaps only one-fifth of the time of buildings, which were scheduled for fifty years or more.

Mr. A. W. Brace (Aluminium Laboratories, Ltd.) emphasised the merits of plotting the whole polar curve of reflectivity as briefly referred to in Dr. Scott's paper, though it was essentially a research practice involving complicated apparatus and considerable time.

### Industrial Applications

*Anodic Finishes for Decorative Applications*, by Mr. T. E. V. Stephenson (Alcan Industries Ltd.);

*Anodic Finishes for Electrical Insulation*, by Mr. J. J. Lee (Aluminium Development Association);

*Anodic Finishes for Wear Resistance*, by Mr. W. J. Campbell (Hard Aluminium Surfaces Ltd.).

Stephenson concentrates primarily on architectural applications, the volume of which has increased markedly over the last ten years. Attractiveness and durability of anodised aluminium is exemplified by entrance doors and windows which after twenty-five years at Banbury remain in excellent condition, although the techniques of anodising then available were much inferior to those of the present day, and no maintenance was possible during the war years.

The restricted range of colours available for exterior architectural work is noted but two further dyes which are virtually as good as new after five years outdoor exposure are indicated. These are Durand and Huguenin Aluminium Fast Red B3LW and Aluminium Turquoise PLW.

Built-in colour is, however, the subject of greatest interest to-day, and while the grey colour from aluminium-silicon alloys is well known, great interest attaches to the Alcoa "Duranodic" and Kaiser "Kalcolor" processes which, in addition to giving a limited range of coloured effects, provide particularly hard films.

Domestic uses, household fittings, jewellery and printing applications are all mentioned, although in these fields satisfactory products have been available for many years and consequently few developments have occurred recently.

Lee's paper covers a new field of application. The uniform anodic film, able to withstand temperatures of the order of 500° C., with a high dielectric strength, good heat transfer characteristics, and high resistance to thermal shock, compares very favourably with some insulants used at present, while the anodised aluminium wire or strip windings have good space factors. In practice, however, there is still considerable work needed, both on the electrical properties of the materials and on the techniques of handling, before these advantages may be enjoyed to the full in many fields of application. A number of service examples are shown including an aluminium foil wound transformer and a helical wave-guide (utilising wire).

While ordinary anodised films have useful abrasion resistance, this property can be greatly improved by anodising in a colder solution than normal. This process is known as hard-anodising and Campbell, one of the originators of such processes, gives a comprehensive account of the properties and applications of hard-anodised aluminium. How hard is hard-anodising is a

question discussed in the paper, and quantitative data are given from the various abrasion methods, including impingement, rubbing and scratching, as well as hardness indentation. These tests show clearly that for any particular application the test method must be as closely related as possible to the anticipated service.

Campbell describes the hard-anodising processes available and points out that two important factors in the Hardas process are the accurate control of the cooling circuit and of the A.C./D.C. ratio which is necessary to control burning. The paper concludes by noting some of the limitations of the hard-anodising process and indicating, as with ordinary anodising, the great necessity for the designer to consult with the anodiser in advance.

### Discussion

In opening the discussion, Mr. G. W. Weeks (The de Havilland Aircraft Co., Ltd.) commented on the difficulty in deciding the sequence of processing for parts which have to be partly hard-anodised and partly conventionally anodised, possibly both in chromic and sulphuric acids, but in answer Mr. Campbell indicated that there was no universal technique, but that the sequence for each job had to be considered on its merit in the light of past experience.

Mr. R. Cooper (Rotax, Ltd.) quoted an interesting aircraft application of hard-anodised S.A.P. material used for a sliding contact operating at high temperatures where, in some cases, flaking of the coating occurred. Mr. Campbell indicated that while the most common cause of flaking was interruption of the current during the anodising process, he had experienced in one case a spontaneous flaking at room temperature of the film produced in an oxalic acid electrolyte at a very high current density.

To anodise or not to anodise architectural work provided controversial discussion, with Mr. P. Gardiner (Gardiner Sons and Co., Ltd.) advocating unanodised aluminium for components more than 30 ft. from the ground, as at such a distance both anodised and unanodised material would have a similar appearance with comparable maintenance. He also advocated the use of a two-coat cellulose acetate butyrate lacquer system, cleaned down and renewed every three years. However, Mr. Stephenson advised that treatments of this type could cause unsightly surface appearance due to slight corrosion under the lacquer, and that in any case in the more industrial atmospheres these lacquers would not last three years.

Mr. H. Mason (Central Electricity Generating Board) was concerned at the difficulty in colour matching in the very large areas of cladding utilised for power stations, often requiring selection of individual sheets or groups of sheets. Stephenson indicated that this was the only satisfactory and economic way in which an acceptable colour match could be obtained, and that it was standard practice in North America.

Mr. R. E. Jennings (Foster Transformers Ltd.) felt that at present aluminium windings could only be economically justified in special cases, and improvements in the sealing practice were, in any case, necessary before they could become more widely used. Possibly the greatest use of aluminium in electrical windings might still be with unanodised aluminium using a separate interturn insulation material. Barrier layer anodic coatings were mentioned by Mr. A. G. Bruce (Ferranti, Ltd.), but although these give good voltage breakdown characteristics they are very susceptible to mechanical damage.

On the question of cost, Mr. H. H. Vevers (Aluminium Wire and Cable Co., Ltd.) indicated that 20% to 30% savings in wire costs were possible with continuously anodised wire in the large and medium size range, while fabrication in anodised aluminium merely required some limitations in winding tensions and bend radii, and the use of such equipment items as plastic winding pulleys. High friction could be a trouble, but this was readily avoided by the use of transformer oil coatings on the anodised wire. Special joining methods, utilising either soldering or mechanical compression had been evolved for the anodised aluminium. Mr. R. Cooper (Rotax, Ltd.) noted that they could operate anodised aluminium windings at 400° C., but they were not entirely happy with the use of this material because of joining difficulties and also because of fatigue under vibration conditions at these high temperatures.

## Advances in Anodising Techniques

*Some Pre-anodising Techniques for Decorative Work*, by Mr. V. F. Henley (W. Canning and Co., Ltd.);

*Techniques for Architectural Anodising*, by Capt. J. Fox-Williams (Williams and Williams Ltd.) and Mr. H. L. Watts (Crittalls, Ltd.);

*Multi-Colour Dyeing of Anodised Aluminium*, by Mr. P. Millett (Millett Levens (Engravers), Ltd.).

Sulphuric acid anodising of aluminium gives a clear translucent film, and hence the texture prior to anodising is of paramount importance. Henley gives practical hints for obtaining a range of surface textures and also for matching the different alloys, forms or material batches. Interstage etching, repeated anodising, chemical bright dipping and electropolishing are all used with mechanically polished surfaces, while for a satin or matt finish, processes such as "liming," ammonium bifluoride etching, sand blasting and vapour blasting are practical propositions. During the anodising process itself adjustments of conditions to minimise attack on the base metal will assist in matching films on different alloys.

For architectural anodising, Fox-Williams and Watts accept that alloy H9 to B.S.1476 gives optimum properties for most applications and that, as a result of considerable research, detailed processing requirements for the anodic film can now be given with confidence. Colour provides difficulty in that only black and gold are readily obtainable commercially. Some interesting figures are given of the cost of pre-anodising treatments showing that, for example, a buff finishing treatment can cost as much or more than the anodising itself. Exposure trials over 2½ years are quoted showing the merits of cleaning at regular intervals. For protection during transport and on site, the relative merits of adhesive tapes, waxes and lacquers are discussed.

Millions of coloured labels and nameplates in anodised aluminium are produced each year. For mass production work, the process involves the production of printing plates which print ink-resists on the surface of previously anodised aluminium, the sheets then being immersed in a dye bath to colour the uncoated areas. A further coating of resist then retains this colour where required; the remainder of the colour is bleached out and a further

colour incorporated in the exposed part of the anodic film before yet another resist application to retain the second colour where required. Up to eight colours can be incorporated in this way and it is also possible to obtain three dimensional effects by etching. The paper by Millett describes the basic sequences involved, which are noteworthy for the amount of precision engineering included and the careful attention to cleanliness at all stages.

The second part of Millett's paper deals with an automatic anodising unit which his firm has installed. This incorporates both the anodising and the dyeing sequences in the production of labels, the sheets being removed intermediately for the application of the resists.

### Discussion

In discussion, the need for maintenance of exterior architecture raised many controversial points. Three anodised aluminium structures in London were mentioned as showing deterioration, though Mr. Waud (The New Century Cleaning Co., Ltd.) assured people that they had been regularly cleaned. However, in one case the building had been erected before the present rigorous standards for architectural work had been fully evaluated, while in another case, the disfigured components were found upon subsequent examination not to meet the specification requirements of thickness. Mr. Waud mentioned two high curtain wall structures in the Barbican Redevelopment Scheme in the City, one with anodised and lacquered aluminium and the other with lacquer on mill finish aluminium. These two buildings, now being completed, would form an interesting comparison in future years.

Dr. Spooner (Aluminium Laboratories, Ltd., Kingston) referred to some five-year tests of his in Montreal which showed little difference between surfaces which had and which had not had a regular weekly clean with soap and water (anodic film 0·001 in. thick).

However, he admitted that the severe winter conditions in Montreal might have a significant effect on the weekly clean. Mr. E. W. Hill (The City of London Real Property Co., Ltd.) referred to the recent formation of a British Institute of Cleaning Science, indicating the interest which was now taken in the correct maintenance of buildings.

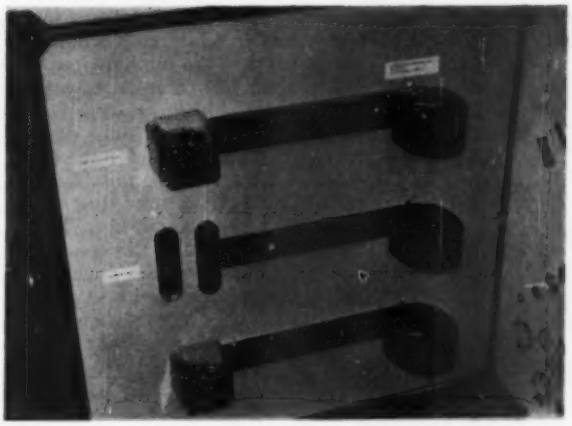
## Anodising—Theoretical Considerations

*A Theory for the Formation of Anodic Oxide Coatings on Aluminium*, by Dr. J. Murphy and Mr. C. E. Michelson (Olin Mathieson Chemical Corporation);

*Characteristics of Barrier Type Coatings for Electrolytic Capacitors*, by Mr. R. W. Franklin (Plessey Co., Ltd.);

*Study of the Growth Process of Primary Films on the Surface of Aluminium*, by Prof. H. Ginsberg and Dipl.-Phys. W. Kaden (Vereinigte Aluminium-Werke, A.G.).

Murphy and Michelson's model of the anodic film remedies some of the inadequacies of the existing model, and is based on the idea that the outer porous portion of the anodic film on aluminium contains at least two "kinds" of oxide: a relatively anhydrous material probably present as particles surrounded by a second "kind" of oxide, a hydrous and hydrogen bonded oxide. In this model, the internal surfaces surrounding the submicrocrystallites of relatively anhydrous material are considered to consist of the hydrous oxide containing anions of the anodising acid—an important innovation. These internal surfaces are considered to be an essential



**Continuous anodising and dyeing of strip (Acorn Anodising Ltd.), with examples of simple manufacturing processes carried out after finishing.**

structural feature of the outer porous portion of the anodic film formed in acid electrolytes.

Franklin shows that the barrier layer films, which for many years were regarded as being substantially homogeneous in composition and uniform in thickness, have in addition to the anhydrous amorphous alumina some hydrated amorphous alumina occurring as a layer at the oxide/electrolyte interface with crystalline $\gamma$-alumina of small crystallite size occurring in agglomerates within the amorphous oxide. Moreover, the barrier layer contains holes and other imperfections probably occurring primarily where unanodisable impurities arise either from the metal or from the solution. These imperfections control many of the properties of capacitors utilising barrier layer films and, in most cases, the behaviour of the anodic oxide dielectrics can be explained by considering them as layers of perfect insulating material penetrated by numerous, minute, conducting regions.

Ginsberg and Kaden have studied the effect of forming a thin barrier layer on aluminium which already has an oxide film present, either as a result of brightening, boiling in ammoniated distilled water, or anodising in sulphuric acid. From the electrical characteristics during the barrier formation process and measurements of capacity and resistance on the finished product, the authors derive some interesting relationships between the surface roughness and dielectric constant, as well as quantitative data on the thickness and specific resistance of the barrier layer. The highest purity of aluminium does not give the best efficiency and residual current: the optimum purity is rather lower.

### Discussion

The Murphy-Michelson model of anodic film structure received some support from Dr. F. Sacchi who felt that sealing could be more readily explained by this model, and from Mr. G. H. Naylor who felt that it allowed greater scope for the even distribution of dyestuffs. The majority of the speakers suggested that even the Murphy-Michelson model did not account for many of the known facts. Mr. A. W. Brace (Aluminium Laboratories Ltd.) mentioned that different anodic film thicknesses form on grains of different orientation and that the model did not adequately explain the relative inclusion or exclusion of

ions such as chromates, phosphates and oxalates in their respective anodising processes. Work at Aluminium Laboratories, Ltd., had shown that the sulphate ion was built into the anodic film from the commencement of formation. Dr. G. C. Wood (Cambridge University) could not see how selective drying out of films during preparation of electron micrographs could give the films shown in many published photographs, notably the electron-micrographs of Booker. Mr. Kape (Aluminium Laboratories, Ltd.) felt that the more than linear increase of corrosion resistance with film thickness was not explained by the vertical pore structure model, nor did it explain why the hardness of the film was greater next to the metal. Mr. H. F. Church (Electrical Research Association) emphasised the essential need for purity in preparing barrier layer films, noting that chlorides only needed to be present in the boric acid anodising solution in quantities greater than 1 part in $10^6$ in order to reduce the resistivity : they had found values for the anodic film of up to $5 \times 10^{15}$ ohm. cm. He also noted that two-stage anodising with a boric acid anodising stage following oxalic or sulphuric acid anodising gave much better results in electrical windings than ordinary sulphuric acid anodised films sealed in boiling water.

Professor Ginsberg in amplification of his paper, noted that homogenisation of the alloys does not always improve the quality of the anodic film with the lower purities of metal.

## Theory of Ancillary Processes

*Theoretical Aspects of Electrolytic and Chemical Polishing*, by Mr. A. W. Brace and Mr. J. M. Kape (Aluminium Laboratories, Ltd.);

*The Theory of Dyeing Anodic Finishes*, by Dr. C. H. Giles (Royal College of Science and Technology, Glasgow);

*The Influence of Sealing Water Impurities on the Quality of the Oxide Film*, by Mr. H. Richaud (Pechiney);

*The Sealing of Porous Anodic Oxide Films on Aluminium*, by Dr. T. P. Hoar and Dr. G. C. Wood (University of Cambridge).

Brace and Kape regard electropolishing as a combination of macro-smoothing (i.e. levelling) and micro-smoothing (i.e. brightening), the former being largely accounted for by the concentration of current at the high points on the surface resulting in reduction of the grosser peaks, while the latter arises from slight differences in rate of diffusion of aluminium ions through the surface oxide film, or because of diffusion of reaction products due to small local differences in thickness. The proportion of macro- and micro-smoothing varies however with different solutions.

Chemical polishing in phosphoric-acid-based mixtures is considered to be governed by the presence of a passive film and a viscous layer. A rather different mechanism is proposed in the case of the nitric-hydrofluoric acid chemical polishing solutions, where macro-smoothing is explained in terms of surface geometry, while the nitric acid again assists in a passivating rôle. The evidence for regarding electrolytic polishing as an extension of chemical polishing is strong.

Giles regards dyeing of anodic finishes as comprising three stages, in the first of which there is film etching and a thin layer of alumina is dissolved, giving an increased specific surface area which then rapidly absorbs a surface layer of dyestuff before slow inward diffusion of dye occurs into the pore of the film. Chemically, the mordant dyes form chelate complexes with the alumina while the sulphonated acid wood dyes either form a covalent bond between their sulphonate groups and aluminium atoms in the surface or enter into an ion exchange reaction at the surface as charged anions singly or as micelles.

The extremely high light fastness of some dyes on anodic films is believed to be due mainly to the blockage of the pores in the sealing process, whereby access of the air and moisture necessary to maintain the fading reaction is restricted. If this is so, it is uncertain why similar effects cannot be obtained with other dyes.

Richaud has investigated the effect of sealing in dilute salt solutions comparable in impurity contents with natural waters. Cations investigated included sodium, calcium, magnesium, iron and copper, while anions were phosphates, silicates, fluorides and hypochlorites. As determined by conductance, only silicates seriously inhibit the sealing action, but both the phosphates and the silicates allow considerable permeability of the oxide layer to inkspots. A test in which the sealed film is dissolved in nitric acid confirms the harmful effect of silicates and phosphates but shows that copper and iron are almost as bad : it is suggested that these latter act by forming a bimetallic couple rather than by inhibiting sealing.

It is particularly noteworthy that these tests do not show any adverse effect of calcium or magnesium in the solution, in view of the fact that many tap waters have been found unsatisfactory for sealing.

These tests are being extended by exposures in marine and industrial atmospheres.

Work by Wood at Cambridge University, sponsored by the Aluminium Development Association, was made available to delegates at the Conference as it related to a study of the sealing of porous anodic oxide films by measuring electrical characteristics. Full details of the work however have yet to be published.

### Discussion

In opening the discussion, Dr. B. A. Scott (British Aluminium Co., Ltd.) noted that a fluctuating redox potential was significant in chemical polishing, and this had been shown by adding manganese to a polishing solution which enabled a visual fluctuation of the solution colour from purple to colourless to be observed. Manganese was of course much closer to aluminium than copper in the electrochemical series. Mr. R. Pinner (Consultant) suggested that Brace and Kape's explanation of the action of the " Erftwerk " solution was inadequate, and that the fine effect was obtained by diffusion control.

It was interesting to speculate whether chelate bonding produced dye films of greater stability than otherwise, and whether the inorganic pigments with their smaller ions would penetrate further and hence give more durable results than the larger organic dye molecules. Although Dr. Scott supported the theory that the conjoint presence of water and oxygen was necessary for a fading of dyestuffs, Mr. G. H. Kissin (Kaiser Aluminum and Chemical Corporation) and Mr. G. H. Naylor both quoted examples where water and oxygen were excluded and yet fading had occurred, the former mentioning that low humidity conditions had given more fading than high humidity exposures.

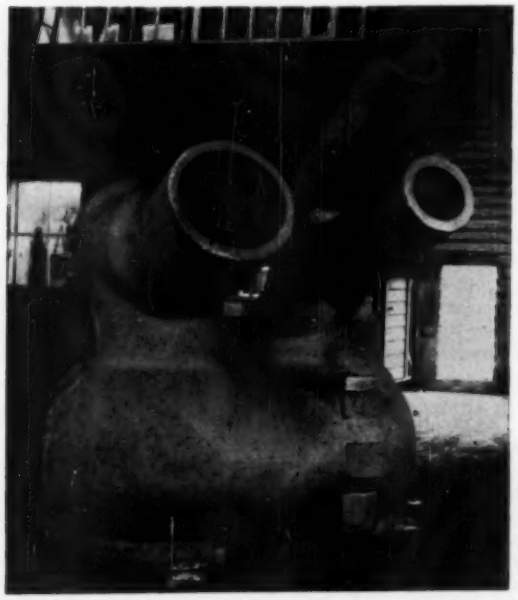
" What is good sealing ? " enquired Dr. Scott, pointing

out that we expected the same reaction to develop the maximum electrical properties, to give maximum resistance to the fading of dyestuffs and, more important and most widely adopted, that the sealing baths should develop maximum corrosion resistance. He also gave his opinion that good sealing was usually accompanied by some bloom but Dr. Kissin disagreed, quoting nickel acetate as a good and bloom-free seal. On Mr. Richaud's paper, DR. SCOTT suggested that inclusion of an accepted British test for sealing, such as the sulphur dioxide/humidity test and the acetic acid/salt spray corrosion test would give valuable additional data in addition to the outdoor exposures now in hand. Richaud's paper, however, clearly established that a recommendation attributed to Schenk that acid dragged over into the sealing bath should be neutralised with sodium phosphate was a bad one. DR. KISSIN reported the adverse effect of organic material in sealing water, noting that this could be present even after passage through a deionising column. DR. F. SACCHI (I.S.M.L., Italy) rather surprisingly thought that too much importance had been attached to the use of very pure water for sealing, and that for practical purposes the use of nickel salts for sealing was good practice because, irrespective of the quality of the water that was being used, the nickel hydroxide precipitate which formed was able to over-ride other effects. Nickel sulphate was more stable than nickel acetate, but with nickel sulphate some fading out of organic colour could occur. Nickel formate was a useful compromise, but in practice sulphate ions were introduced by carry-over from the anodising bath and again bleeding of the organic colours occurred.

# Co-operation in Casting Design

TWO sets of intercept steam chests for the West Thurrock 300MW. turbine generator installation have been ordered by A.E.I., Ltd., from the steel casting division at Jarrow of Armstrong Whitworth (Metal Industries) Ltd. The first of these left and right hand sets has just been completed and provides an interesting example of better quality casting as a result of interchange of ideas between the foundry and the A.E.I. design team.

The basic specification of the steam chests calls for molybdenum-vanadium high temperature steels for operation at pressures of 700 lb./sq. in. at temperatures of 1,050° F. From the foundry point of view, three proposals—two of them of major consideration—were made to facilitate casting and these were adopted in the final design, as detailed below.



**One of the intercept steam chests showing the branch ends (right) which were tapered to assist directional solidification**

*Directional Solification.*—The original design of the branch ends contained thickened end sections to allow for machining so that a blanking plate could be mounted for pressure testing of the castings. This, however, produced the problem of flaws due to centre-line shrinkage caused by the irregular proportions. The possibility of leakage around the studs on which the blanking-off plate was mounted and difficulties in subsequent welding also arose. Foundry proposals were accepted and the final design eliminated the thickened ends and included a tapered wall thickness of 2¼ in. to 1½ in. at the extremity to assist directional solidification. The casting was pressure tested without the need for studs and, after testing, was machined to the original drawing dimensions to allow welding to the next section of the turbine installation.

*Support of Branch Cores.*—The possibility of disturbance in the flow of steel around the conventional chaplets used to support the cores, and the prospect of incomplete fusion, led to re-design to incorporate a 6 in. diameter hole at the neck of the two branch pipes. This permitted support of the loop pipe branch core by means of a bolted tie-bar, a method which not only avoided metallurgical difficulties, but which provided a more secure method of preventing movement of the core. The facing of this hole will be subsequently machined and a cover plate bolted to the casting.

*Mounting.*—The original provision for integral casting of the brackets by which the chests are handled and mounted have been discarded because of the danger of cracking and unsoundness. The castings now include a simple pad on which the mounting brackets will subsequently be bolted.

The chests were subjected to gamma ray and grinding/crack detection inspection.

## Blast Furnace Record

THE No. 3 blastfurnace at the Clay Lane Ironworks of Dorman Long (Steel), Ltd., has produced two million tons of basic iron since it was brought into commission in December 1956. This is a record tonnage from the larger blast furnaces now operating in this country. The furnace is still in commission and will continue into 1962 before re-lining will be necessary.

# National Physical Laboratory Extensions

## Basic Physics — Autonomics — Mechanical Working

THE start of work on three important new research buildings at the National Physical Laboratory, Teddington, was formally inaugurated on Monday, 2nd October, by Mr. Richard Thompson, M.P., Parliamentary Secretary to the Ministry of Works, when he poured the first skip of concrete into a supporting pier of one of the buildings. The ceremony took place on the site of a new four-storey building for the staff of the basic physics division of the laboratory. Nearby, work has started on a laboratory block for the autonomics division, and on another part of the station a mechanical working laboratory is under construction for the metallurgy division.

Altogether, these three schemes will cost about one million pounds and represent the largest block of development on the Teddington site since the war. The mechanical working laboratory should be ready in December next year, the basic physics building in February 1963, and the autonomics building in May 1963. The need for these buildings has arisen as a result of the reorganisation at the laboratory in 1958, when some divisions were regrouped and others created. The new buildings now going up are for three divisions at present inadequately housed in buildings scattered over a fairly wide area of the N.P.L. site and in urgent need of new quarters. In addition, the new buildings will provide improved research facilities and a whole range of new scientific equipment.

### Unusual Features

The basic physics building and the autonomics block have been so planned by Ministry of Works architects that they will form an interesting and distinctive precinct, flanked on one side by a wing of the existing radio-chemical laboratory. The quadrangle thus formed will have lawns, shrubs, and trees and an ornamental pool to give a focal point. Some unusual features are being incorporated in these new buildings.

The autonomics building, where research will go on into various aspects of automation and automatic control systems, will have a silent room on the ground floor, weighing 54 tons, which will be mounted on a separate, resilient foundation. This is virtually a concrete room inside a concrete room so that the inner chamber is completely isolated from outside noise. Next to this will be a vibration-free room for neurophysiological research on animal vision and hearing which will be screened all round to prevent electrical interference from outside sources. A suite of dust-free rooms will also be provided, arranged to give progressive degrees of cleanliness, the final one eliminating dust particles entirely. On the ground floor will be the computer room which will have a specially designed suspended floor for easy access to the electrical services beneath it.

Recent research into autonomics has led scientists to believe that the most fruitful results can be expected from combining the latest knowledge and techniques in physiology, psychology and physical chemistry with those in mathematics, electrical engineering and physics. Animal learning and human perception are examples of processes which, when they are better understood, will help the evolution of automatic methods and greatly improved forms of automation in the future.

The new autonomics building will be the first single laboratory of its kind in the world to be entirely devoted to this work. Part of the study that will go on there will be into nerve behaviour in animal systems, which it is hoped will throw light on the design of mechanical systems. The animals used for these studies will be kept on the top floor of the building, which will be fully air-conditioned.

The research programme of the autonomics division also includes very high speed computing techniques, mechanical translation of scientific Russian into English and automatic recognition in print.

### Constant Temperature Rooms

The basic physics building for the study of the physical properties of materials in relation to their ultimate chemical nature, will incorporate eleven rooms in which constant temperatures can be maintained, in most cases to limits of $\pm 1°$ F. Individual air-conditioning units will be fitted in each room capable of cooling, heating, humidifying and de-humidifying. In addition, a dust-free laboratory will be provided with air-conditioning plant designed to exclude all particles down to 1 micron in size.

A notable feature of the design of the building is that half its 320 ft. length will be supported on five massive concrete piers which will carry it over the public right-of-way leading to Bushey Park, thereby forming a link between two previously separated portions of the N.P.L. site. Three of these columns will be exposed and the other two enclosed in a glass screen forming the library and entrance hall.

It is difficult to foresee the exact future of the work of the basic physics division or its influence on more applied fields. But it is certain that knowledge of the relationship between the properties of bulk material and its molecular skeleton is the best guide to others who try to change the chemical composition in such a direction that the macroscopic properties are improved.

### Specialised Equipment

The mechanical working laboratory is being built for the metallurgy division, one of whose functions is research directed towards understanding the factors which lead to improved strength and ductility of alloys. This work concerns alloys at both normal and high temperatures so that its results will apply equally to motor cars and building structures as to aero engines and rockets. The new building will aso enable the division to carry out research on materials such as titanium, niobium and chromium.

Among the equipment which the Ministry of Works

will provide will be a specialised sheet mill capable of rolling sheet to a thickness of a thousandth of an inch and less, and a 700 ton extrusion press which will extrude a billet 9 in. long by 3 in. in diameter into a rod 27 ft. long by ½ in. in diameter in less than a second. A metal-lined concrete pit 33 ft. deep and 2 ft. 6 in. in diameter will be built to take the rods as the come from the press.

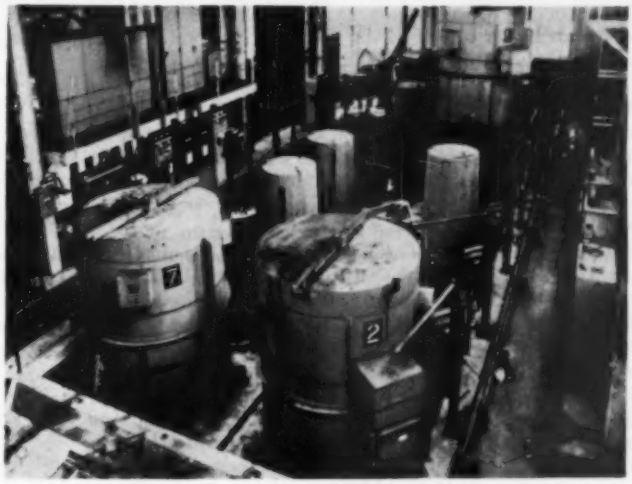
A number of metals such as titanium or niobium, in which the metallurgy division is interested, can be heated with safety only in a vacuum. For this purpose a vacuum furnace will be installed which will reach 1,700° C. and yet allow the heated metal to be taken out of the furnace within ten seconds.

There is a possibility that the mechanical working laboratory will at some time in the distant future be affected by major re-development plans at the National Physical Laboratory. Because of this the Ministry of Works has designed the building of bolted steel construction with as many prefabricated parts as possible, so that the maximum amount of materials will be recovered should the building one day have to be dismantled and moved to another site.

# Eight Bells at Forge Lane

FOR twenty-six years Richard Johnson & Nephew Ltd., have been bright annealing copper wire and strip in Efco bell furnaces. The first installation in their factory at Forge Lane, Manchester, was a single furnace which could be moved to any one of three bases where the charge was sealed under a heat-resisting steel hood and protected with an exothermic atmosphere produced from town's gas. Now a building has been erected to house a new Efco installation in a modern layout planned to provide the utmost convenience, not only for the handling of charges and the operation of the furnaces, but also for the transfer of work into and out of the department.

The centre of the building is used for the handling of charges and on both sides of this central handling position, provision is made for two parallel production lines each consisting of two furnaces and eight bases. Three of these production lines are in operation, and foundations have been laid for the fourth line to complete an 8 bell 32 base installation, each base capable of accepting a 2 ton charge. The protective atmosphere is supplied by five Efco exothermic generators, each having a capacity of 2,000 cu. ft./hr., mounted on an overhead platform along one side of the new shop. The atmosphere is delivered to a ring main feeding the individual bases. When the installation is complete not more than four generators will need to be used simultaneously.



**Two of the production lines for bright annealing copper wire and strip : each line comprises two Efco bell furnaces and eight bases complete with work stands, baffles and hoods.**

The furnaces operate at temperatures up to 550° C. and are rated at 120 kW. They are heated by elements of nickel-chromium strip arranged in sinuous form and supported around the chamber walls. The temperature of each furnace is controlled automatically by an indicating and recording instrument housed with contactors, fuses and pilot lights in separate floor standing cubicles.

The furnace bases take a charge 54 in. high, in a baffle having a diameter of 39 in. The work is placed on a charge stand supported from the hearth, and beneath the stand is an atmosphere recirculating fan of patented design. The charge in its baffle is covered with a hood which makes a gas-tight seal with the furnace base. The baffle shields the charge from direct heat radiation from the hood and directs the flow of atmosphere in a definite path around and through the charge. The hoods and baffles are made of aluminised steel.

The furnaces are accurately positioned over the bases by engagement with locating posts. Electrical connections are made automatically as the furnaces are lowered over a charge with an audible indication should an atmosphere recirculating fan fail to operate. Provision exists for water spraying the hoods to speed the cooling of charges.

## International Patternmakers Ltd.

INTERNATIONAL PATTERNMAKERS, LTD., a British export company has just received a substantial repeat contract for high quality metal patterns and foundry tooling from a leading West German motor car manufacturer. With its head office in Darlington, International Patternmakers, Ltd., was formed in 1959 by a group of master craftsmen patternmaking firms in Birmingham, Darlington, Leamington, Leeds, Leicester and Manchester to develop the export of pattern equipment, dies, foundry tooling and equipment, and is probably the largest organisation of its kind in the world. Contracts have been successfully completed for foundries in Sweden, West Germany, Portugal, Switzerland, Yugoslavia and Israel, and the company is rapidly building up a world-wide connection.

# News in Brief

ASSOCIATED ELECTRICAL INDUSTRIES, LTD., and Enfield Cables, Ltd., have now transferred all their business in paper insulated and polythene insulated telephone cables, and in co-axial and other high grade cables for telecommunications to Telephone Cables, Ltd., Chequers Lane, Dagenham, Essex. Telephone Cables Ltd., formed in January this year and jointly owned by A.E.I. and Enfield Cables, is now handling all home and export business in this field for both companies.

SCHLOEMANN A.G. are building for the Bremen mill of Klöckner-Werke A.G. five side-trimming and cross-cutting shear lines for cold rolled steel strip. They are to be laid out to handle coils weighing up to 36 tons, of material in gauges from 0·020 in. to 0·120 in. thickness and up to 6 ft. 9 in. width, with strip speeds of up to 325 ft./min.

THE Manchester office and warehouse of Norton Grinding Wheel, Co., Ltd., is now Wharf Road, Sale, Cheshire. (Tel: Sale 8285/7; Telex: 66116).

ASSOCIATED ELECTRICAL INDUSTRIES' EXPORT COMPANY has successfully negotiated a contract worth £4½ m. to supply the Republic of Indonesia with telephone cable. The cable will be manufactured by Telephone Cables, Ltd., of Dagenham, an AEI subsidiary owned jointly with Enfield Cables, Ltd.

BIRWELCO, LTD., the G.K.N. subsidiary, has made an exclusive agreement with Yuba Consolidated Industries, Inc., of Tulsa, Oklahoma, to manufacture and sell Aimco Transaire air-cooled heat exchangers in Europe and the British Commonwealth. Birwelco has already received several large contracts for this type of equipment from both the oil and chemical industries.

A NEW division, to handle the design, construction and installation of electrical and mechanical precipitators is announced by Joy-Sullivan, Ltd. This move is the result of the merging, in 1959, of Western Precipitation Corp., of Los Angeles with Joy Manufacturing Co. of Pittsburgh, parent company of Joy-Sullivan, Ltd. A sales office has been established at 7 Harley Street, London, W.1. (Tel: Langham 7711.)

OUTPUT from the Lackenby universal beam mill of Dorman Long (Steel), Ltd., which began commercial production in July 1958, now exceeds 1 million tons.

ASSOCIATED ELECTRICAL INDUSTRIES, LTD., has received an order worth £231,000 from the State Electricity Commission, Victoria, Australia, for 6·6 kV. auxiliary switchgear at the Commission's Hazelwood power station.

STEWARTS AND LLOYDS, LTD., have been awarded, through Atlas Lighting, Ltd., a contract for the supply of 104 tubular steel lighting columns with 40 ft. mounting height for the Park Lane, London, improvement scheme. This will be the first installation in Great Britain of lighting columns with lamps mounted at 40 ft. Considering the mounting height the columns are extremely slender, having an outside diameter of 8⅝ in. at the base, reducing to 3½ in. at the top. The bracket arms have an outreach of 8 ft. 6 in.

BARCLAYS BANK D.C.O. states that it has been reported that a Canadian Company, the Magnet Consolidated Mines, Ltd., of Toronto, is seeking permission to mine bauxite in Jamaica and that the application is now under consideration by the Ministry of Development.

FOLLOWING an enquiry received at the British Trade Fair in Moscow this year, an order for industrail *p*H measuring, recording and controlling equipment worth £15,000 has been obtained by W. G. Pye & Co., Ltd., from the official U.S.S.R. buying agency, Mashpriborintorg.

THE VISCO ENGINEERING CO., LTD., incorporated in 1921, has changed its name to Visco, Ltd.

CROFTS (ENGINEERS), LTD., power transmission engineers of Bradford, have extended their stockholding service to their London branch. Extensive modifications at 36/42, Tanner Street, Bermondsey, London S.E.1 (Telephone: HOP 7751/4), have enabled Crofts to offer what is believed to be the largest and most comprehensive power transmission stockholding service in the country. The technical and estimating service is being further augmented at these new offices under the management of the London director, Mr. H. W. Cameron.

RECORD deliveries of 111,723 tons of finished castings were made from the iron foundry of Distington Engineering Co., Ltd., a subsidiary of The United Steel Cos., Ltd., during the year ended 30th September 1961. Exports of finished castings—such as ingot moulds—to Continental steelworks are now running at a new high level, despite strong competition from Common Market countries.

WILD-BARFIELD ELECTRIC FURNACES, LTD., have received a further order for mains frequency induction heated equipment for Japan. In this case, the equipment will have a nominal capacity of 650 lb. molten aluminium and will be employed for the low pressure diecasting of automobile engine components.

THE Power-Gas Corporation, Ltd., of Stockton-on-Tees, a member of the Davy-Ashmore group, has been appointed main contractors by Magnesium Elektron, Ltd., for the engineering of a new plant to produce 5,000 tons of magnesium a year at Hopton, near Wirksworth, in Derbyshire. The plant will extract magnesium of 99·9% purity from local dolomite by a thermal reduction process which has not previously been operated on a commercial scale in this country.

THE Borough of Widnes have accepted the tender of Dorman Long (Bridge & Engineering), Ltd., amounting to £139,000 for the demolition of the Widnes Transporter Bridge which crosses the River Mersey and the Manchester Ship Canal. Demolition of the old bridge, which was built in 1905 and consists of approximately 3,000 tons of steel and iron, is scheduled to be completed in two years.

A TRADE mission consisting of over twenty senior representatives of the French steel industry visited Britain from the 2nd to the 7th of October, as guests of the Steel Works Plant Association, with the object of studying recent developments in British rolling mill and ancillary equipment. They visited ten plant manufacturers and steelworks in the Sheffield and Middlesbrough areas and in the Midlands.

THE PLESSEY CO., LTD., announces the conclusion of negotiations to lease from the Swindon Corporation a further 50,000 sq. ft. factory at Cheyney Manor, Swindon. The factory is expected to be used for expansion of the company's industrial hydraulics division.

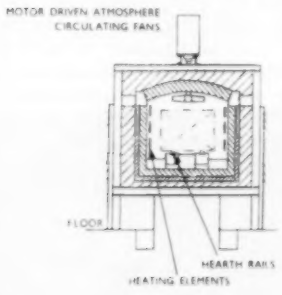
# Continuous Furnace for Annealing Whiteheart Malleable Iron Castings

## Installation for Monthly Output of 100 tons

**General view of the furnace from the charging end.**

THE Birlec gaseous process of annealing whiteheart malleable castings has become very well known over the last fifteen years, this important development having been used principally in the many installations of elevator type batch furnaces both in this country and abroad, designed and built by AEI-Birlec, Ltd. It has been most successful and a significant part of the output of whiteheart castings is now produced in this way.

Over the last few years, an alternative design of furnace has become available, mainly applicable to foundries with outputs of at least 20-25 tons per week. It is a continuous unit and the first one in this country of 100 tons per month nominal output has been put into service at Bullers Ltd., Tipton, Staffs., where it has been operating very successfully for several months. Other furnaces, for installation abroad, for outputs 50% and 100% greater than this are under construction.

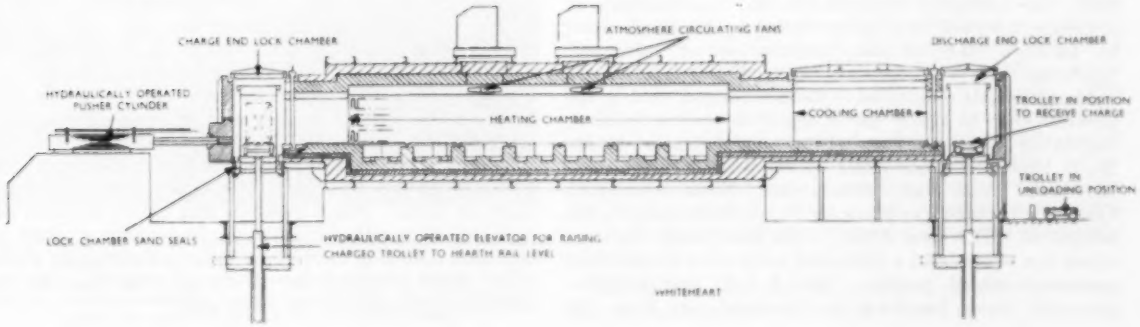



**Longitudinal and transverse sections through the furnace.**

Messrs. Bullers have operated three 300 kW. Birlec elevator furnaces for a number of years, but a considerable part of the production has comprised castings which do not need to be spheroidised, for which the continuous furnace is ideal. Of course, reheating of heavier castings for a spheroidising cool could be carried out either in the elevator furnaces or in a separate furnace associated with the continuous one if required.

The continuous furnace now installed is of the pusher type and is electrically heated, although gas-fired versions are available. The castings are loaded in trays which comprise cast nickel-chromium alloy grids surmounted by specially designed containers, the grids themselves being supported on cast nickel-chromium alloy shoes which rest on the rails running through the equipment.

The furnace comprises an entrance lock chamber—with hydraulically operated elevator for bringing the charge trolley with tray to hearth level—a heating chamber, a cooling section, and an exit lock chamber similar to that at the charge end. The construction is such that gas tightness is maintained throughout. The trays, in line on the rails, are projected forward at the required intervals by a hydraulic pusher at the charge position. All movements are hand controlled


CHARGE END LOCK CHAMBER
ATMOSPHERE CIRCULATING FANS
DISCHARGE END LOCK CHAMBER
HYDRAULICALLY OPERATED PUSHER CYLINDER
HEATING CHAMBER
COOLING CHAMBER
TROLLEY IN POSITION TO RECEIVE CHARGE
TROLLEY IN UNLOADING POSITION
LOCK CHAMBER SAND SEALS
HYDRAULICALLY OPERATED ELEVATOR FOR RAISING CHARGED TROLLEY TO HEARTH RAIL LEVEL
WHITEHEART

but a timing device gives warning to the operator to discharge and re-charge one tray at pre-set intervals.

The atmosphere for the process is obtained by introducing into the chamber a pre-determined flow of humidified air, produced with the assistance of an electrically heated water heater included with the plant. The uniform decarburising of the castings is ensured by the use of two fans in the heating chamber and atmosphere composition is indicated by a $CO_2$ recorder continuously.

The furnace is rated at 250 kW. and the heating elements, which are located on the side walls of the chamber, are divided for correct control into three zones. The elements are of heavy nickel chromium tape supported by replaceable pins, and very adequate insulation is provided for economic operation at the comparatively high temperature used. Temperature control is by indicating instruments, and a three point recorder is also fitted. Electrical equipment is of the usual type and arrangement, with modern safety features incorporated.

At present a 76 hour cycle is being used, one tray being discharged every 4 hours. Each tray has a normal capacity, with suitable castings, of approximately 11 cwt., its volume being about 13 cu. ft., corresponding to 95 lb./cu. ft. With some castings this loading cannot be achieved and, therefore, the full nominal output is not obtained, but in other cases the cycle can be much reduced and/or the loading increased to give more than the nominal figure.

It is too early to give actual operating costs but it is known that they will be low in relation to other methods of annealing whiteheart castings, as in the case of the elevator furnace using the gaseous process, of which data have been published previously in the technical press.

# Carborundum's Golden Jubilee

SOME seventy years ago, Dr. Edward Acheson, inventor, scientist and industrialist discovered that the reaction, at very high temperature of a mixture of clay and powdered coke produced crystals which were so sharp and hard that they could scratch glass as easily as a diamond. The material proved to be silicon carbide and was named " Carborundum " by Acheson, who formed a company of the same name to market the new product—the first man-made abrasive. Marketing in this country was at first placed in the hands of agents, but demand for grinding wheels, hones and abrasive grain grew so rapidly that in 1911 the parent company set up its own selling organisation—The Carborundum Co., Ltd. In the same year it was decided to cater for the rising demand by building a factory in Trafford Park, Manchester, where manufacture of both silicon carbide and fused alumina products began in 1913.

Since that time development has been continuous, and customers now have a choice of abrasive material, abrasive size, bonding agent, and hardness and density of each product, and the large selection of shapes and sizes of the finished product available ranges from a dentists' drill to segmented grinding wheels of 72 in. diameter for use in heavy engineering work. In recent years a new division has been formed to produce and market a complete range of coated abrasives.

In 1922 the range of products was extended to include refractories since, apart from their abrasive characteristics, silicon carbide and aluminium oxide had long been recognised as highly efficient refractory materials. In 1927 the company commenced the manufacture of crucibles, followed by a further factory extension in 1928 to facilitate the growing production of refractory products.

Many special events have been arranged during the present year to mark the company's Golden Jubilee, beginning on 4th January with a special concert by the Halle Orchestra, conducted by Sir John Barbirolli, in the Free Trade Hall, Manchester. More recently, a Celebrity Lecture was given by Dr. J. Bronowski on the subject of " The Year 2,000." The Free Trade Hall was again the venue, and a thousand seats were reserved for grammar school pupils. The A.A.A. and athletics generally have benefited by financial aid from the company, and individual presentations have been made to all company personnel, who have also had several social events arranged for them during the year.

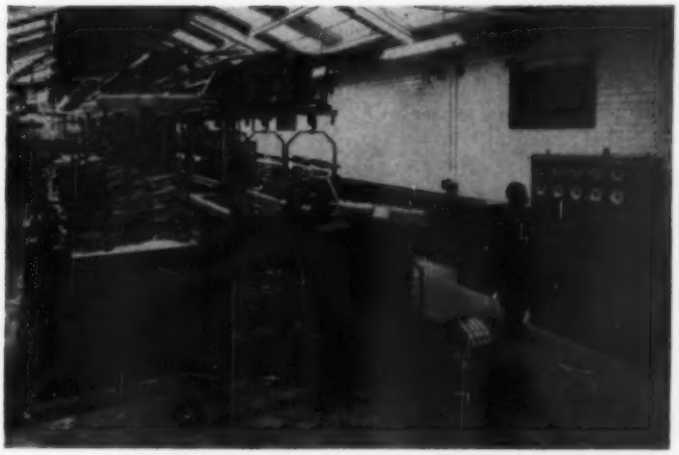
The importance of industrial and instructional films was early appreciated by the company, which set up its own film unit some thirty-five years ago. Several Carborundum training films have attracted considerable interest outside the organisation, including one devised to coach slower readers and bearing the title " Speed up your reading." Three of the company's new industrial films were recently shown to the press in London, the first, "The Winning Tip," dealing with the use of ceramic-tipped cutting tools, and illustrating the considerable savings in time and cost consequent upon their adoption. The second film, entitled, " Heat in Harness," shows the great use made of high-duty refractories in a wide range of industry, as examplified by zinc production, non-ferrous founding, vitreous enamelling, and the making of Phurnacite briquettes. " To be Precise " is the title of the third film, which covers such precision operations as the finishing of racing car gears and astronomical mirrors to tolerances of less than one micro-inch, and the grinding of such diverse objects as artificial eyes, snooker balls, crystal cut-glassware, etc. Each of these films is in 16 mm. sound and colour, and runs for some twenty-five minutes.

## High-Duty Medium Section Mill

THE Hütten- und Bergwerke Rheinhausen A.G. has placed a contract with Schloemann A.G., Düsseldorf, for the construction of a new medium section mill. There are to be two roughing trains to secure the high planned monthly output of more than 35,000 tons of widely varied products, and the intermediate and finishing trains are to be of generously spaced, staggered arrangement. As a result thereof, and through the incorporation of hydraulic gear for traversing the stands, a change in the mill schedule will require only a minimum of time. When medium and heavy sections are being rolled it will, for example, be possible to start up the production of a different shape on one part of the mill, whilst manufacture of the previous item on the schedule continues on the other part.

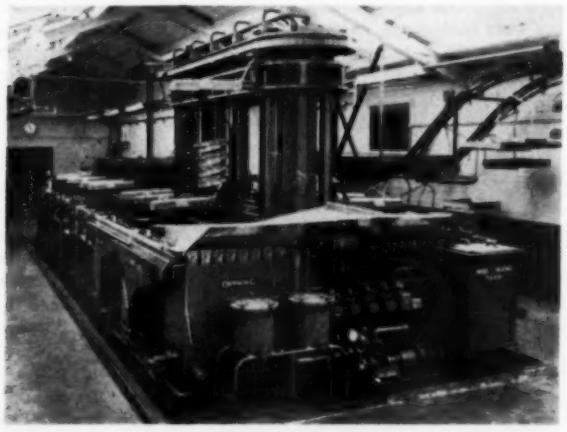
# Automatic Plating of Motor Cycle Wheel Rims

## Triumph Install Canning Trojan Unit



**A general view of the Trojan plant showing the control panel and an unloaded jig.**

A NEW type of plating plant, the only one of its type in the country, has recently been installed at the Coventry works of Triumph Engineering, Ltd. It is a special Trojan hydraulic return-type unit for the nickel and chromium plating of Triumph motor cycle wheels rims; other items such as kick start levers, silencers and brake levers, can also be catered for. Designed and manufactured by W. Canning and Co., Ltd., of Birmingham to meet Triumph's stringent specification requirements, the plant is claimed to be unique in that it employs the multiple cell plating principle; instead of progressing through the bright nickel tank, the work is set down in one of eight different sections or cells, with the rims held horizontally in the jig and surrounding a fixed central core of nickel anodes. Since the work is stationary, it is possible for the anodes to be positioned so that the most efficient current distribution is obtained. The introduction of this new type of automatic has enabled Triumph to increase considerably their output of plated motor cycle rims, and at the same time ensure a standard of finish to a degree of uniformity never before achieved. On a production of 40,000 rims the reject figure has been less than 0·1%.



**Jig of rims being transferred from one of the B.Q. Super bright nickel plating cells to the rinse tank and travelling over the stationary jigs in the nickel plating cells. In the foreground is a Sentinel filter unit and also the plating-out unit for the bright nickel plating tank.**

It is interesting to note that although it employs the most up-to-date mechanical techniques the plant is basically an automated version of a rim plating plant introduced by W. Canning and Co., Ltd., over 50 years ago. In this plant the rims were plated horizontally with a centre anode, the arrangement ensuring that an adequate deposit of nickel was applied to the inside of the rim. While this method has continued in use, it was not applicable to the conventional methods of automatic plating.

### Two-Storey Layout

The Trojan plant supersedes manually-operated equipment and is housed in a new two-storey building. Rectifiers, pumps, compressed air equipment and other ancillary plant are on the ground floor whilst the actual plating plant is on the floor above, thus allowing more operational room. The plating shop has acid proof tiled floors and a modern exhaust system extracts fumes from the plating shop and dust from the polishing shop.

The overall dimensions of the plating plant are: length 47 ft.; width 13 ft.; and height 12 ft. It is basically in two sections: the first section, comprising the cleaning and chrome plating tanks and swills, is of standard Trojan design, whilst the other section is made up of the specially designed nickel plating tanks. The work arm is transferred between the two sections by means of a solenoid-operated pick-up pawl and carried to a vacant nickel station by a pusher fitted to an overhead transfer chain. An indexing switch determines the loading sequence of the nickel stations, energising a solenoid-operated lifting and lowering pawl at the empty position.

The Trojan plant has an output of 48 rims per hour, the process sequences being as follows :—

| *Operation* | *Immersion Time* |
|---|---|
| Load jigs | |
| Hot soak cleaner | 2½ minutes |
| Cold swill | 2½ minutes |
| Hot electrolytic cleaner | 2½ minutes |
| Cold swill | 2½ minutes |
| Cold swill | 2½ minutes |
| Acid etch | 2½ minutes |
| Cold swill | 2½ minutes |
| Cold swill | 20 seconds |
| Bright nickel plate | 46 minutes |
| Cold swill | 40 seconds |
| Cold swill | 2½ minutes |
| Chrome plate | 5½ minutes |
| Drag out | 2½ minutes |
| Neutraliser | 2½ minutes |
| Cold swill | 2½ minutes |
| Cold swill | 2½ minutes |
| Hot swill | 2½ minutes |
| Unload jigs | |

Loading and unloading of the plating jigs are accomplished by one operator. The work arms are provided with additional hooks so that standard type plating jigs may be used in place of those for rims.

During the acid etch process the work is immersed for 2½ minutes but, by means of a timing device, the rectifier is only switched on for the final 45 seconds. By this means an evenly etched surface, without any pickling effect, is achieved before the voltage is applied. A system of counterflow rinses is employed after most processes, and is a distinct advantage both in saving water and producing a much cleaner final rinse.

Appreciable economies in nickel consumption have resulted from the new method of plating. Using the old method, the rims had to be "overplated" by as much as four times the calculated processing time to ensure that the spoke band—usually attracting least nickel—received a sufficient thickness. The rim beads attracted four times as much as the spoke band. This ratio has now been substantially reduced. Apart from the economies effected in nickel consumption, the ductility and adhesion of deposit have also been improved.

Automatic plant employing the cell plating principle can be usefully applied to the plating of many components which are either of complex shape or which need special anode configurations and for which manual processing has in the past been necessary if undue variations in thickness of deposit were to be avoided.

# Automated Anthracite Process Saves Waste

COMPLETE automation of heavy media processes, long an objective in coal and iron ore preparation, is reported in an installation in the Pennsylvania anthracite industry. A closed loop control system by the Underkoffler Coal Service Company of Lykens has substantially lowered costs by permitting the preparation of coal with uniform ash content. It also allows recovery of low-ash coal previously discarded as waste.

The scheme is a collaborative development of Wilmot Engineering Company, a leading manufacturer of heavy media equipment, Industrial Nucleonics Corporation and the American associates of Honeywell Controls, Ltd. At the Underkoffler plant, which processes 600 tons of anthracite per day, control is interlocked to a series of valves and mechanical devices to maintain the specific gravity of the water-magnetite medium in the separatory system at optimum value, and to add magnetite automatically as needed. Control of gravity is held within ±0·003.

### Proportioning Control

Units used are an electronic circular chart recorder, an electric proportioning unit, a graduated motor, and an AccuRay density measuring unit employing gamma radiation.

The Wilmot heavy media system is a double-hulled vessel with a three-compartmented sump. Fast-draining medium underflowing the lead end of the vibrating screen is sluiced directly to the main medium sump for recirculation to the media vessel. Magnetite remaining is spray-washed into a washings hopper as the coal moves along the vibrating screen. This is pumped to a magnetic separator, which collects and concentrates the magnetite, passes it through a demagnetising coil, and returns it to the main medium sump. Magnetite is further recovered by spray washing at the discharge end of the vibrator; this solution is recovered in a counterflow hopper and recirculated through sprays over coal above the washings hopper. Magnetite recovery is said to be so complete that only 0·4 lb./ton of raw coal feed is required.

The AccuRay unit, which operates on the principle of radiation absorption being proportional to the mass it penetrates, measures to within 0·001 the specific gravity, 1·70, of the medium as it enters the heavy media vessel. The radiation source is mounted on one side of a short section of pipe ahead of the media vessel, and the radiation detector on the opposite side of the pipe.

### Magnetite Added Automatically

The electrical signal from the detector is amplified and printed on the electronic recorder. Depending upon gravity, the electric proportioning unit controls either of two motorised valves: one to bleed the circulating medium to a magnetic separator for densification, the other to add fresh water to dilute the medium. The unit also controls a graduated motor which, in turn, operates a rate-adjusting rheostat on the magnetite feeder.

In addition to the main controls, the system also includes an AccuRay level detector on the main sump, from which the medium is circulated, and a recording-controlling ammeter on the coal feed to the heavy media vessel. Off-normal sump level automatically adds water to the sump, if the density is too high, or by-passes medium to the magnetic separator on a low reading. The ammeter measures the current drawn by the motor driving the coal feed, shutting down the magnetite feeder if the coal feed falls below a prescribed minimum value.

Before installation of the automated heavy media vessel, the Underkoffler Company processed 400 tons of coal per day with jigs using water as the separatory medium. Where ash content of the prepared coal previously ranged from 12 to 16%, it now averages 10–11%.

# Continuous Casting of Copper Alloys

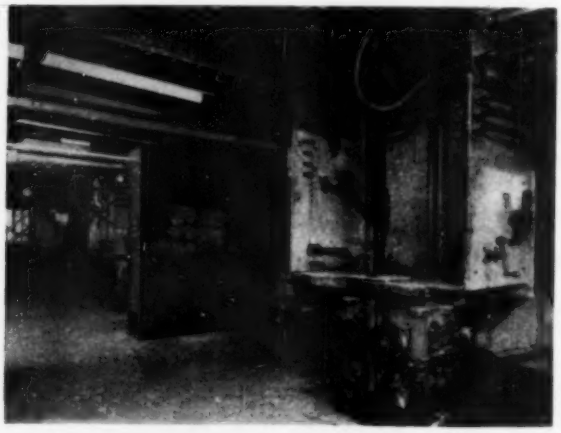
## Expanded Production at Enfield Rolling Mills

MAJOR plant extensions for the continuous casting of Encon rods, tubes and shapes have recently been completed at the Brimsdown, Enfield, Middlesex, works of Enfield Rolling Mills, Ltd. The new installation, which has doubled production, had become necessary due to the success Encon continuous cast alloys have enjoyed since their introduction less than five years ago. This increased production has also permitted a wider range of sizes and materials to be held in stock, enabling delivery to be made at short notice from over 1,500 stock items. In addition, speedier delivery of special orders for non-stock items will be possible. New storage and despatch facilities have been erected for delivery direct to customers and depots at Newcastle, Paisley, Cardiff, Belfast, Leicester and Manchester.

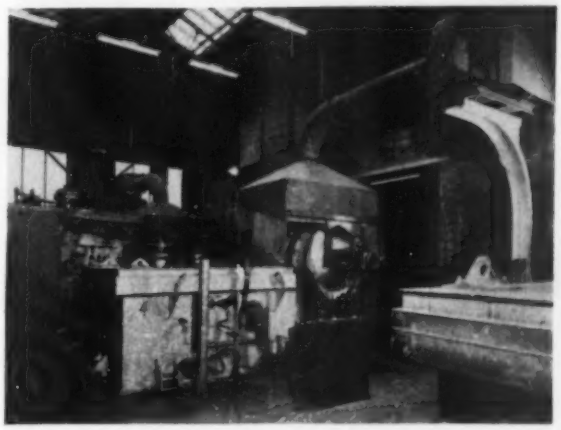
### The Product

Appropriate size rod and tube can be selected for bushes, bearings and other parts. By choosing the correct size, machining time, metal and tool wear are saved. Exact lengths up to 12 ft. can be purchased, thereby saving metal usually wasted by short end scrap. It is claimed that, in contrast to metal cast by other methods, continuously cast material is greatly superior in respect of freedom from blowholes and other casting defects. By comparison with sand and chill cast metals, the properties of Encon alloys are striking. For B.S.1400-PB1 alloy, the elongation is 10% minimum (chill 3% and sand 1·5%) and the U.T.S. is 23 tons/sq. in. minimum (chill 19 and sand 13 tons/sq. in.).

Continuous castings are made to any of the B.S.1400 specifications for phosphor bronzes, leaded phosphor bronzes, gunmetals and leaded gunmetals. Castings are also made to other specifications as required. Stock sizes for rod are $\frac{7}{16}$–6 $\frac{1}{16}$ in. diameter, and for tube $\frac{25}{32}$–6$\frac{1}{16}$ in. O.D., with a minimum I.D. of $\frac{13}{32}$ in. Lengths greater than 12 ft. can be supplied, if necessary, and all bars are mechanically straightened to give no more than $\frac{1}{4}$ in. arc depth in 5 ft. The dimensional tolerance on the outside diameter of continuously cast rod and tube is + 0·004–0·006 in.; tubes are concentric to within 1$\frac{1}{2}$% of wall thickness.



**Continuously cast tube passing through the withdrawal rollers on its way to the cutting floor below.**



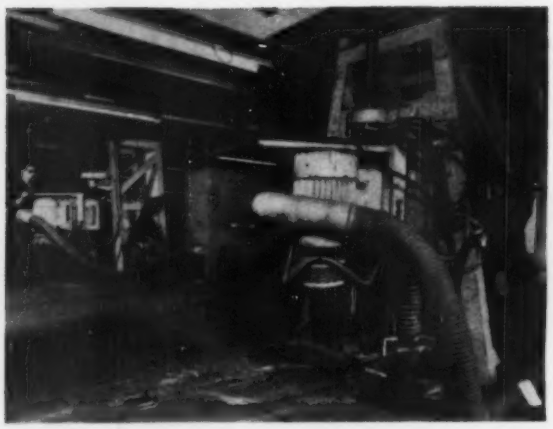
**General view of the furnace floor showing a Birlec-Detroit rocking arc melting furnace and a casting furnace.**

### Production Methods

*Casting*

The continuous casting plant is similar to that developed by the American Smelting and Refining Company, of New Jersey, and is operated under licence from that company. The method is in principle extremely simple—the virgin metals are melted, held in an atmosphere of nitrogen, and cast through graphite dies. The vertical cast bar passes through guide rollers on the floor below the die, and is cut off into lengths on a lower floor. Considerable care and laboratory control are exercised to achieve the casting perfection and dimensional tolerances required in Encon materials; particular ingenuity is needed for the design and construction of the dies necessary for the casting of complicated shapes.

The constituents of the alloy to be melted are weighed out into skips in wheeled bogies, and elevated to the top floor of the four-storey casting building. They are then tipped into a 500 lb. capacity Birlec-Detroit rocking arc furnace. When the melt is ready, the arc furnace is tipped hydraulically and the molten alloys transferred to the charging box of the continuous casting furnace. This furnace is lined with refractory, and is heated by carbon resistors. An inert atmosphere of nitrogen is maintained in the furnace to prevent oxidation of the melt. The graphite die is located in a water cooling jacket at the base of a graphite crucible; a shut-off



**Two machines for cutting to length the continuously cast material.**

**The new despatch bay showing some of the stock racks.**

plug is provided to close the channel through which the molten metal flows to the die, the handle controlling this plug being on the casting floor below the furnace.

To start the casting operation, a starter bar is inserted into the underside of the die, and, with the furnace shut-off plug in the open position, the starter bar is drawn steadily down by the roll mechanism on the casting floor. The speed of withdrawal is adjusted to that the metal freezes as it passes through the cooled die. By the time the metal reaches the outlet of the die, it is sufficiently solid to support the mass of liquid metal above, and casting continues as long as the cooled metal is withdrawn at constant speed from the die. The starter bar is removed when the cast bar or tube emerges from the roll mechanism.

*Cutting to Length*

The newly-cast bar or tube is cut into lengths by a horizontal resin-bonded abrasive wheel. The cutting-off unit is clamped on to the downward-moving stock, and is counterpoised by a heavy weight or by hydraulic means ; it is aligned by rollers running on the faces of a vertical steel column of hexagonal cross-section. The cut section is received in a vertical tube which is pivoted so that the sections may be drawn out on to a horizontal roller-type run-out table. The tube or rod is inspected and dimensionally checked on this table and, after being straightened on a Farmer Norton machine, is passed to stock or for despatch as required.

*Die Life*

The life of a die in continuous duty can exceed a hundred hours, but as a new die is used each time a particular size is cast, the average life is about six hours. Die wear during a cast is negligible. The graphite dies are made in a machine shop adjacent to the main casting building ; it is equipped with lathes, band-saws and drilling machines, all connected by ducting to a highly efficient dust-removal system. The throughput of metal for each die is from 100 to 800 lb. /hr. ; and in the course of its life-time the die may pass anything from 500 lb. to 15 tons of metal.

*Machining*

As large sections of the engineering industry prefer to buy fully machined parts, a well equipped machine shop has been installed for the production of finished bushes, bearings, washers, valve guides and so on. This facility should be of special value to manufacturers faced with sudden heavy orders in excess of capacity.

### Future Expansion

In the planning for the new Encon plant, provision was made for additional expansion in the future, so that production will always keep up with the demand. Confidence that this further expansion will be necessary is already justified by the rising demand created by the enlarged stocks of Encon metals.

## Air-Propane for Rail De-stressing

A CHEAPER and more efficient method of de-stressing continuously welded rail, using specially-designed air-propane burners, has been successfully adopted on the Eastern and Southern Regions of British Railways. The burners, developed by The British Oxygen Co., Ltd., at the request of British Railways, are used to warm rail to between 65° and 75° F. before it is fastened down. This enables the continuous rail to withstand successfully subsequent stresses of expansion and contraction in varying weather conditions. Of the heat sources tried out for rail de-stressing propane has proved by far the most successful—due largely to its easy handling and high vapour pressure at low temperatures.

The air-propane de-stressing unit consists of a trolley supporting four heating muffles and four 100 lb. propane cylinders. Each muffle houses two air-propane burners, which are fed from the cylinders.

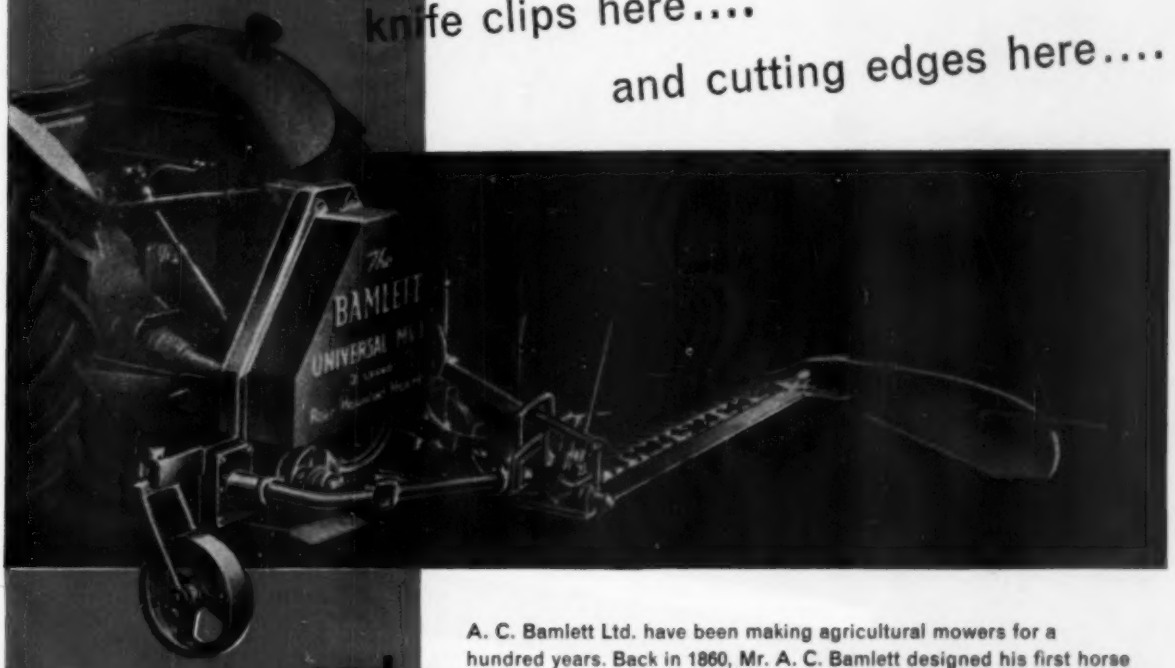
De-stressing is carried out by moving the trolley slowly along a section of track with the heating muffles directed against the continuously welded rail. The temperature rise is assessed by measuring the amount of expansion which takes place. When the temperature of a 500 yd. length of rail is raised from just over freezing point to 70° F., it expands approximately 4 in. This heating operation would take about 1¼–1½ hours. Use of the air-propane burner by British Railways will help speed up their use of continuous rail, which will result in considerable saving in wear and tear of fastenings, rails, rolling stock, and in track maintenance.

There's a knife head here....

a connecting pin here....

knife clips here....

and cutting edges here....




and they're all case-hardened in a 'Cassel' salt bath furnace

A. C. Bamlett Ltd. have been making agricultural mowers for a hundred years. Back in 1860, Mr. A. C. Bamlett designed his first horse drawn mower. It is a tribute to his ingenuity that the firm still use the same principle today, when the horse has long since been replaced by the tractor.

In an era of increasing mechanisation in farming, Bamlett's have kept their leading place by their enlightened outlook on manufacturing techniques. The principle may date from 1860—but the methods belong very much to the 1960's.

They became dissatisfied with their method of heat-treatment and, after investigation, decided to instal an I.C.I. 'Cassel' salt bath to help them case-harden those parts of their mowers that were most subject to hard wear.

They case-harden to a depth of .015/.025"—and have found that with the 'Cassel' bath they can easily control this depth, which gives uniform results and longer life to the treated parts.

In addition, their output has doubled for the same labour, and their costs have been reduced.

Bamlett's would certainly agree that

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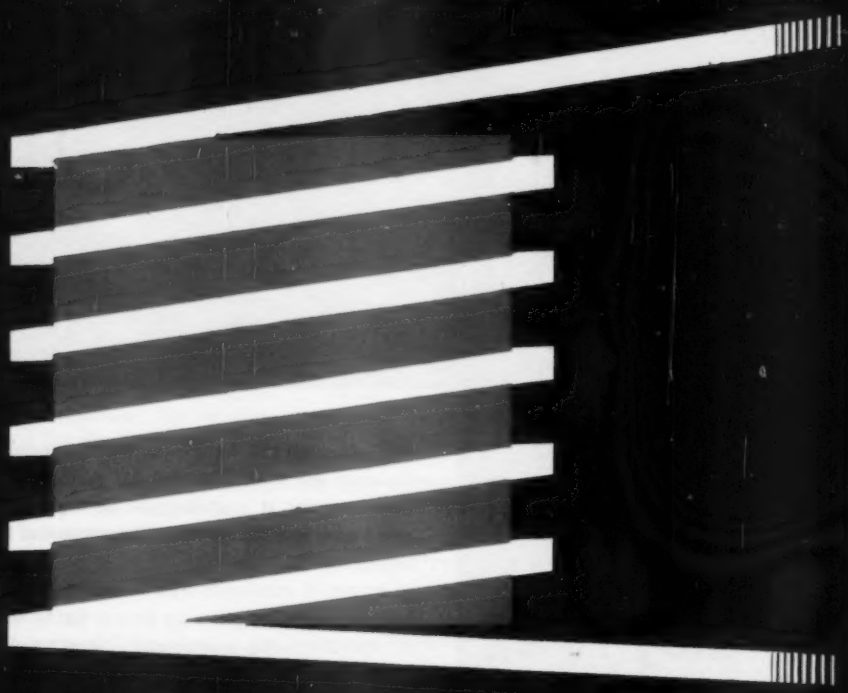
GENERAL CHEMICALS DIVISION

# INDUCTION FURNACES



The resources and expert knowledge of G.E.C. and the British GECO Engineering Company Limited combine to provide G.E.C. furnaces for all induction heating purposes. These include furnaces for the induction heating of non-ferrous metals. If you have a problem concerned with induction heating or melting, bring it to G.E.C. Their specialists will be glad to help you.

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# NEWS AND ANNOUNCEMENTS

## Cathodic Protection Course

A VACATION course on "Cathodic Protection—Instrumentation, Interference and Interference Testing"—organised with the co-operation of the Corrosion Group of the Society of Chemical Industry—will be held in the Department of Metallurgy, Battersea College of Technology on 19th and 20th December, 1961. The course will cover the following aspects of the subject: types of tests used in cathodic protection; instruments and characteristics of instruments; commissioning and maintenance instrumentation; special topics—half cells, redox potentials, constant potentials; interference—theoretical principles, interference in practice. One lecture will be devoted to a survey of recent developments in this field. All lectures will be by specialists concerned with work in cathodic protection. The fee for the course is £6, and enrolment forms and further information may be obtained from the Secretary (Metallurgy Courses), Battersea College of Technology, London, S.W.11.

## Steel and the Common Market

AT the invitation of the Council of the Iron and Steel Institute, two lectures on the subject of "The British Steel Industry and the Common Market" will be delivered at the Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1, at 6 p.m. on Wednesday, 29th November, 1961. The lecturers will be H. E. Dr. E. N. van Kleffens, head of the delegation of the High Authority of the European Coal and Steel Community in the United Kingdom, and Mr. C. R. Wheeler, C.B.E., president of the British Iron and Steel Federation and a past president of the Institute. Admission will be by ticket only.

## London International Engineering Exhibition

THE largest international exhibition ever to be held in Britain will occupy both Olympia and Earls Court from 23rd April to 2nd May, 1963. To meet changing European trading conditions, the long-established Engineering, Marine, Welding and Nuclear Energy Exhibition is to be transformed into an international exhibition using the million square feet of the two exhibition buildings combined. The exhibition will be called The London International Engineering Exhibition, and it has been timed partly to overlap the Hanover Fair in West Germany. Buyers from all over the world will be able to see both these great events in one short visit to Europe and will, therefore, be attracted to come to both exhibitions in larger numbers than ever before.

The joint organisers are F. W. Bridges & Sons, Ltd. who have run the Engineering, Marine, Welding and Nuclear Energy Exhibition since its inception in 1906, and Industrial and Trade Fairs, Ltd., who organised the successful British Trade Fair in Moscow earlier this year. This will be the first occasion on which both Olympia and Earls Court have been used together for an international exhibition, and some 1,200 exhibitors are expected to take part. The exhibition will be backed by the largest publicity campaign ever launched in support of an international exhibition held in London, in order to attract a record number of overseas buyers.

The exhibition will cater for every type of engineering product from the largest items of capital equipment to the smallest power tools and components. Olympia will, in general, take the heavier exhibits including a welding section—an exhibition in itself—while at Earls Court electrical engineering and a range of lighter products will be on display. Government information stands will be limited to 1,000 sq. ft. each and are expected from a number of European and other countries.

## Export Licence for Ferrous Scrap

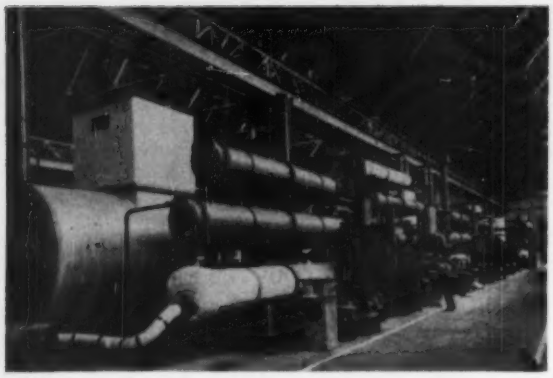
AT the request of the Ministry of Power the Board of Trade announce that arrangements have been made permitting the export of compressed baled iron and steel scrap not exceeding an f.o.b. value of £25 per ton, and of iron and steel scrap turnings and borings not exceeding an f.o.b. value of £25 per ton from 31st October, 1961, until 28th February, 1962. An Open General Licence has been issued permitting the export of this material to any destination during this period. Enquiries about this licence should be made to the Board of Trade, Export Licensing Branch, Gavrelle House, Bunhill Row, London, E.C.1 (tel.: Monarch 4071). Copies of the Open General Licence (price 3d. each, by post 5½d.) can be obtained from H.M. Stationery Office, Kingsway, London, W.C.2 and branches.

## Lead Promotion Plans

THE formation of the European Lead Development Committee to co-ordinate and expand promotional work throughout Europe is announced following meetings in Rome between representatives of the French, German, Italian, Spanish and United Kingdom lead development associations and the Belgian and Swedish lead producers. The L.D.A., London, will be responsible for the secretarial work of the new committee under the guidance of a steering group comprising France, Germany, Italy and the United Kingdom.

The consumption of lead in all forms in Europe has risen in the last four years by about 120,000 tons (11%) to 1,200,000 metric tons in 1960. Preliminary figures for the first half of 1961, prepared by the Committee, show that the growth is continuing for Europe as a whole despite some levelling off in the United Kingdom, where consumption *per capita* is the highest in the world. This expansion in consumption is the result of the steady growth of most uses. Batteries now consume 30% more lead than four years ago, the rise, which is expected to continue, reflecting the more widespread use of motor cars. The use of lead for radiation shielding is also expanding rapidly but precise figures are not available in all countries.

Technical aspects of many lead uses were examined by the Committee. There are interesting differences in the techniques used in various countries for lead cable sheathing and these will be described in special reports shortly to be issued. In sheet and pipe too, there are



**Hydrogen/nitrogen plants in course of assembly at the Smethwick Works of The Incandescent Heat Co., Ltd. The company's gas atmospheres division have orders in hand for packaged nitrogen, hydrogen, carbon dioxide and other gas producing plants for installation in some dozen overseas countries.**

striking contrasts in applications which will be illustrated in forthcoming international publications, showing lead in modern building. Everywhere the need for better sound insulation is creating new demands for lead which, because of its weight and limpness, is specially suitable as a sound barrier.

The meeting completed preliminary arrangements for the first International Conference on Lead to be held in London from 22nd to 25th May, 1962. The emphasis will be in the use of lead for batteries, cables and nuclear shielding and other sessions will cover economic trends and research. The full programme will be announced later. The future activities of the Committee include the publication of technical and promotional booklets and a European lead bulletin in French, German, Italian and English.

## I.S.I. to Visit India

THE council of the Iron and Steel Institute has accepted an invitation from the Indian Institute of Metals and the National Metallurgical Laboratory, Jamshedpur, to hold a meeting in India early in 1963. The main programme will last about a fortnight and will include visits to the Steelworks at Durgapur, Bhilai and Rourkela of Hindustan Steel, Ltd., and the plant at Burnpur of the India Iron and Steel Co., Ltd. The timing of the visit will enable members to take part in a joint symposium on "Recent Developments in Iron and Steelmaking, with special reference to Indian Conditions," organised by the National Metallurgical Laboratory at Jamshedpur. Visits will be arranged to the Laboratory and to the Tata Iron and Steel Co., Ltd., and other works. The meeting will conclude with a visit to Calcutta.

## Aluminium for Building

JAMES BOOTH ALUMINIUM, LTD., one of the pioneers of the British Aluminium industry, is to market for the first time, through its building products division, a range of products designed for the building industry. It has also set up, under the direction of Mr. E. H. Laithwaite, the recently-appointed building products sales manager, a new technical advisory service to architects, builders, plumbers, etc., dealing with the application and installation of products made from aluminium and aluminium alloys.

A feature of the plan is a special building products warehouse at the Argyle Street Works, Birmingham, from which architectural extrusions, corrugated and troughed building sheets, flashing and roofing coil, and the associated fixing accessories, can be supplied immediately from stock instead of produced to order. New plant and equipment is being acquired, as part of the company's overall expansion programme, to enable an even wider range of aluminium building products to be produced.

## Stainless Steel and the Dairy Industry

FROM cow to customer, stainless steel is the lifeline of the dairy industry. This was the theme of the Firth-Vickers Stainless Steels, Ltd., at the Royal Dairy Show, in October. Firth-Vickers are Europe's largest producers of heat, corrosion, and creep resisting steel, and their Staybrite stainless steel plays an important role in dairying, from the milking shed to the delivery of the daily "pinta" This corrosion resistant and hygienic metal has helped to make possible one of the biggest advances in dairy farming techniques in recent years. This is the bulk collection scheme which is steadily replacing traditional milking by bucket and churn. Cows are electrically milked by stainless steel milking machines directly into large refrigerated tanks of the same material. These are regularly emptied into stainless steel road tankers which carry the milk direct from the farm to the bottling plant. At the bottling, pasteurising and sterilising plant, stainless steel is used in vast quantities, because of the need for hygiene and easy cleaning.

Also on display were examples of a new method—developed by Firth-Vickers—of giving highly polished stainless steel sheet a protective covering. The covering, made of PVC or latex backed paper, results from several years of experimental work to avoid unnecessary damage to polished sheet during transit and handling at fabricators' works.

## Steel Beam Production Rationalisation

PROPOSALS are under consideration for a new British Standard which will substantially reduce the number of sizes of steel beams rolled in this country. Such rationalisation should lead to greater economy in steel production and thus improve the position of British makers of structural steel and British fabricators seeking business on the Continent and in other countries. The proposal will permit of more frequent rolling of all sizes in the new list, resulting in speedier delivery, and will assist in standardisation in design, thus facilitating work in the drawing offices.

The only effective way of ensuring cheap steel is by adopting a sensible range of sizes which will enable modern mills designed for mass production to be adequately loaded, and so achieve the minimum production costs of which they are capable. Since the introduction of universal beams in 1958, the number of I and H profiles has risen to 71. Adoption of the proposals which have been submitted to the British Standards Institution will reduce the number to 27.

Recently two more steelmakers have brought into operation universal beam mills and two other mills are planned. The British Constructional Steelwork Association, representing the fabricators, is co-operating with the steelmakers. It is hoped that the new British Standard now under consideration will be established by the end of this year, and that on 1st January, 1963, the existing British Standard covering the sizes and weights of structural steel will be withdrawn.

# Personal News

DR. J. W. MENTER has been appointed director of the Tube Investments Research Laboratory at Hinxton Hall, near Cambridge. During seven years at Hinxton, Dr. Menter has been leading research teams studying the microstructure of metals and has promoted notable advances in the techniques of electron microscopy and X-ray microanalysis.

MR. A. H. MILLS, sales manager of Jessop-Saville (Small Tools), Ltd., has joined the board of the company as sales director, and MR. F. A. LYTTON, export manager, has been appointed to the local board of Jessop-Saville, Ltd., Sheffield, as export sales director.

MR. T. S. J. ANDERSON, C.B.E., T.D., who has been director of studies at the Royal Military Academy, Sandhurst, since July, 1948, will join the staff of Vickers, Ltd., on 1st January, 1962, in the newly created appointment of controller of education and training. This appointment carries the status of a principal officer of the company.

THE British Iron and Steel Federation announces the following appointments: MR. E. W. SENIOR, C.M.G., to be director of the Federation; MR. J. B. COWPER to be managing director of British Iron and Steel Corporation, Ltd.—the industry's main central trading organisation—in addition to his present post of financial director of the Federation; MR. J. DRISCOLL to be assistant director (economics); MR. L. J. GOLLOP to be assistant director (statistics); MR. B. S. KEELING to be assistant director (training); MR. A. H. MORTIMER to be assistant director (commercial); and MR. K. DONOHUE to be secretary of the Federation.

MR. C. W. PAGE has been appointed to the newly created post of sales manager of the industrial division of Castrol Industrial, Ltd.

MR. R. SCHOLEY, works manager (flat products) at The United Steel Cos.' Steel, Peech & Tozer branch, has assumed responsibility for the Templeborough bar mill and the 10 in. and 14 in. mills in addition to the flat products departments. His designation is now works manager (re-rolling mills).

LORD DUDLEY G. GORDON, D.S.O., LL.D., has resigned as chairman of Hadfields, Ltd., and SIR PETER G. ROBERTS, B.T., M.P., has been elected chairman of the company. Lord Dudley Gordon has agreed to remain on the board as an ordinary director until the annual general meeting of the company.

THE Sheepbridge Engineering group announce the appointment of MR. J. T. DAVENPORT as general manager of Sheepbridge Equipment, Ltd. (foundry division), Chesterfield. MR. W. MCLELLAND, of Whitley Bay, succeeds Mr. Davenport as foundry manager of Sheepbridge Alloy Castings, Ltd., Sutton-in-Ashfield, Notts.

MR. T. A. BIRD, manager of roll sales of Armstrong Whitworth (Metal Industries), Ltd., is at present on a round-the-world sales tour, visiting rolling mills in Salisbury, Southern Rhodesia; Johannesburg, South Africa; Sydney, Melbourne and other Australian steel centres; Mexico City and Monterrey, Mexico; and Hamilton and Montreal, Canada.

MR. J. D. DUNLOP, M.C., has been appointed managing director of the Tube Investments subsidiary, New Conveyor Co., Ltd., of Smethwick, designers and manufacturers of mechanical handling plant and conveyors.

DR. W. O. ALEXANDER, assistant research manager, of the metals division of Imperial Chemical Industries, Ltd., has been appointed technical director of Foseco International, Ltd., with effect from 1st January, 1962.

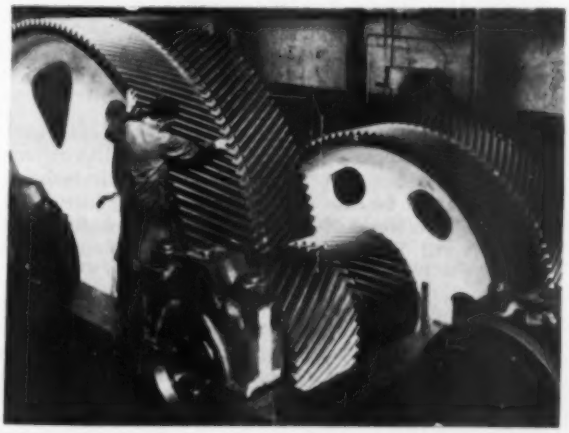
MR. W. H. RIGG has been appointed managing director of Firth Cleveland Tools, Ltd., a member of the Firth Cleveland group: he will operate from the company's Tipton Works in Staffordshire.

MR. R. G. MONKHOUSE, manager of the central engineering workshops at The United Steel Cos.' Workington Iron and Steel Company branch has been appointed works manager (Ickles) at the Steel, Peech & Tozer branch.

DR. D. S. BEARD, who joined the Griffin & George organisation in 1960 from the Norwich City College, where he had been a lecturer in physics and mathematics, has been appointed to the board of Griffin & George (Sales), Ltd., in the capacity of technical sales director.

ENGINEERING director, MR. R. S. MEDLOCK and mechanical meter marketing executive, MR. R. V. MAY, of George Kent, Ltd., recently visited South Africa and South America respectively. Their individual missions, though geographically divorced, were both related to a policy of maintaining close personal liaison between parent company and overseas representation.

MR. H. SMITH, chairman and joint managing director of British Ropes, Ltd., Doncaster, has joined the board of The United Steel Cos., Ltd.



**Pictured at the Salford works of the Jackson Division of David Brown Industries Limited is a 200-ton gear unit which is believed to be the largest ever manufactured in the United Kingdom. Of American design, this unit has been built to the order of Davy and United Engineering Company Limited of Sheffield for installation in the new hot strip mill which they are now building for the Spencer works, Newport, Mon., of Richard Thomas & Baldwins Limited.**

Associated Electrical Industries, Ltd. has appointed a director of manufacturing services: he is Mr. A. C. Main, formerly director of manufacture of A.E.I. (Manchester), Ltd., who now reports to the A.E.I. board through the vice-chairman. He remains as a non-executive director on the board of A.E.I. (Manchester), Ltd.

Mr. L. H. Welch, O.B.E., who retired recently from the position of chief electrical engineer to the London Electricity Board, has been appointed industrial relations consultant to the Electrical Research Association.

Sir Ivan A. R. Stedeford, G.B.E., chairman and managing director of Tube Investments, Ltd., has relinquished the managing directorship, whilst continuing as executive chairman. Sir William Strath, K.C.B., Mr. W. Hackett, Jnr., and Mr. R. D. Young have been appointed managing directors of the group.

Mr. J. B. Simpson, mining consultant to Anglo-French Exploration Co., Ltd., has been elected president of the Institution of Mining and Metallurgy for 1962-63.

Mr. A. W. Scott has been appointed to the board of Armstrong Whitworth (Metal Industries), Ltd. Mr. Scott joined the company in 1949 and will retain the position he has held for the past two years as works manager of the Jarrow foundry division.

Mr. F. Winston Reynolds, founder of Winston Electronics, Ltd., Shepperton, Middlesex, has relinquished his duties as chairman and managing director of the company, and will now devote the whole of his time to the exploitation of their new range of fully transistorised loudspeaking telephones. He is succeeded as chairman and managing director, by Mr. W. Allen Bridges, director of European operations of the Dynamics Corporation of America, of which Winston Electronics is a wholly-owned subsidiary. The board of directors will continue to be Mr. W. A. Bridges, Mr. R. F. Laurence, Mr. J. Samuels and Mr. F. Winston Reynolds: Mr. W. A. Hardy continues as the company secretary.

Dr. W. J. Bates, a well-known figure in the optical world, has left Bristol University to join R. & J. Beck, Ltd., as chief engineer.

Sintered Products, Ltd., of Sutton-in-Ashfield, Notts. (a member company of the Sheepbridge Engineering group), announce that Mr. J. Carter, their technical representative for the area covering Derbyshire, Yorkshire and the North East, will in future include Lancashire, North Wales and North West England in his itinerary.

Pyrene-Panorama, Ltd., of Windmill Road, Brentford, Middlesex, announce that Miss B. P. Park, formerly with Optoshield, Ltd., has been appointed sales manager of their eye protection department. Miss Park has specialised for many years in industrial eye protection, and is widely known throughout the country to both safety officers and safety organisations.

Richardsons, Westgarth & Co., Ltd., announce that: Mr. J. D. Glanville, formerly with the United Kingdom Atomic Energy Authority at Risley, has been appointed a director of the company and has assumed the responsibilities of group production director. Mr. W. R. Jones, managing director of George Clark (Sunderland), Ltd., is now group personnel director, and Mr. H. Watson-Jones, managing director of Westgarth (Hartlepool), Ltd., group commercial director: both remain directors of the parent company. Rear-Admiral J. G. C. Given, managing director of the marine division of the group has left the service of the company. The subsidiary companies (with the exception of Humber Graving Dock & Engineering Co., Ltd.) are now production units with centralisation of the main functions at group headquarters, Wallsend, and no longer come under the direction of individual managing directors.

Mr. I. M. Painton has been appointed publicity manager of James Booth Aluminium, Ltd., Birmingham. The former publicity manager of James Booth, Mr. A. Howard, is continuing to act for the company as manager of technical publications and exhibitions. The new appointment in no way effects Mr. Howard's position with the Delta Metal Co., Ltd., as group advertising and publicity manager, the scope of which continues to grow as the Delta group expands.

Mr. K. B. Hogg was recently appointed general works manager of E.I.L. (Electronic Instruments, Ltd.), Richmond, Surrey. He was formerly general works manager responsible for the five Southern group factories of A.E.I.—the radio and electronics components division.

Mr. R. H. Wormley, formerly Yorkshire area manager, has now been appointed home sales manager of Associated British Machine Tool Makers, Ltd. He has been succeeded at the Leeds office by Mr. W. G. Ormrod.

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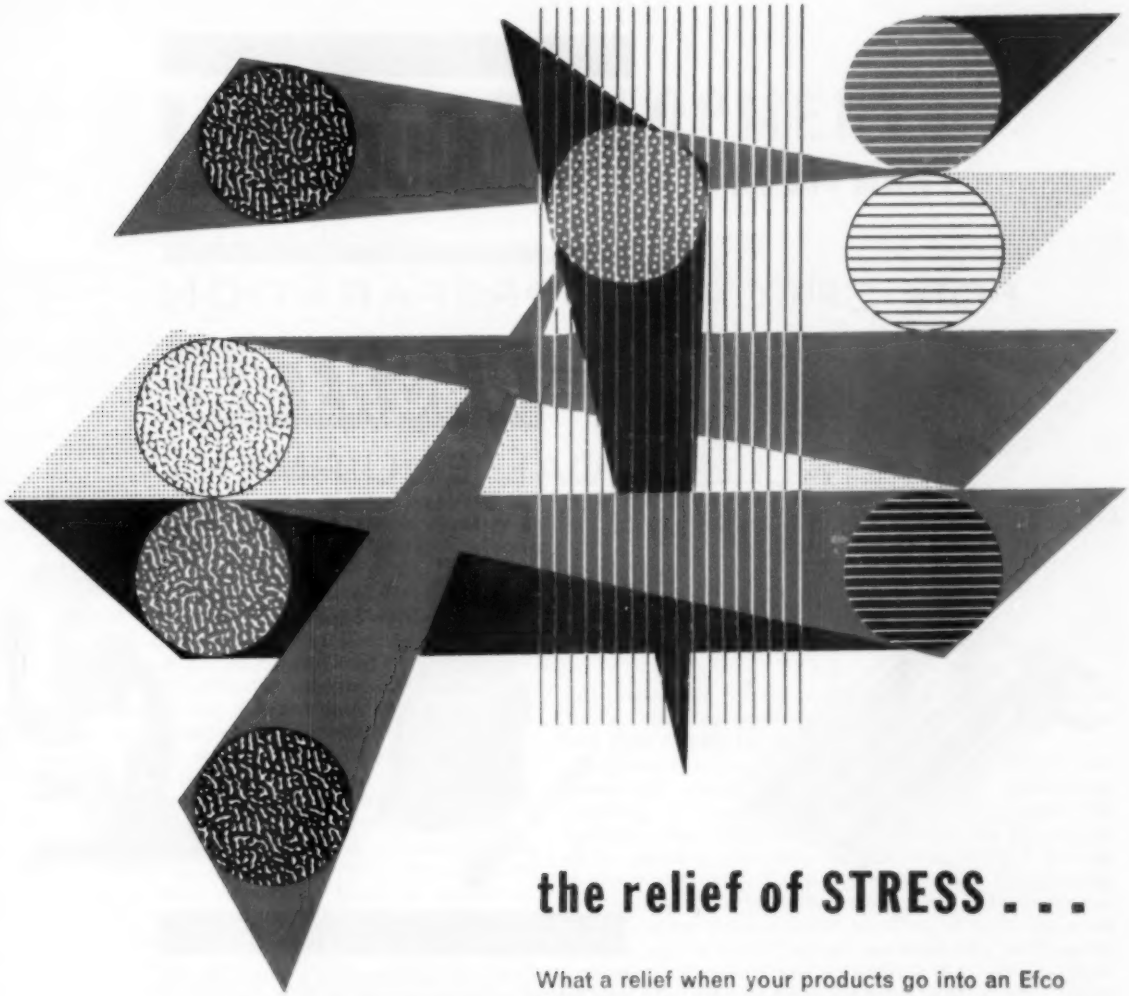
# Obituary

We regret to record the death of the following:

Mr. W. Jenkins Gibson, J.P., financial director of Hadfields, Ltd., and deputy managing director of Millspaugh, Ltd., the Hadfield subsidiary, who died on Friday 29th September 1961, at the age of 63. Mr. Gibson trained as an accountant and joined Hadfields from Peat, Marwick, Mitchell & Co., in 1927, when he was appointed assistant to the secretary. Subsequently he became chief accountant, local director in 1937, and financial director in 1946. A Justice of the Peace since 1954, Mr. Gibson was actively connected with many local voluntary organisations—in particular the Scout movement—and with amateur drama in the Sheffield area.

Mr. R. D. MacMillan, managing director of Controlled Heat & Air, Ltd. (a member of the Incandescent group of companies), who died on 8th November, 1961. Born in Glasgow on 21st December 1903, Mr. MacMillan became a qualified marine engineer, and in 1927 joined the Pneumatic Conveyance & Extraction Co., Ltd., of Manchester, and later the Carrier-Owen Engineering Co., Ltd., of London. In 1933 he joined Controlled Heat & Air Ltd., as chief designer and was appointed managing director in 1945. Mr. MacMillan concentrated mainly on the lower temperature phase of thermal engineering and contributed substantially to the development of continuous tinplate printing machines; dust extraction in both wet and dry forms; related combustion equipment and heat exchangers; and critical control of high velocity convection in continuous static and mechanised forms.



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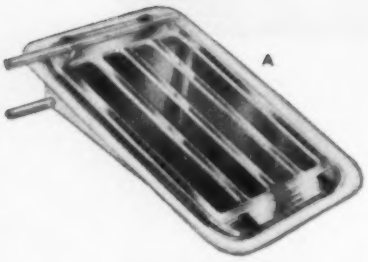


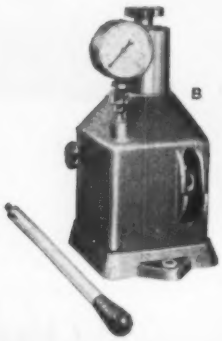


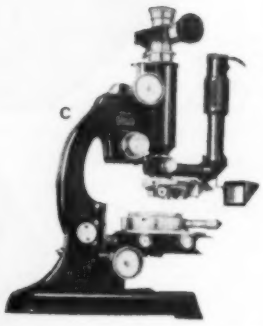


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B **Metallurgical Mounting Presses** For mounting specimens in bakelite or diakon moulds for their speedier and more efficient polishing, etching and examination. Models for mould diameters. 1 in., 1¼ in. and 1½ in. £138. 2 in. £200.

*Also available (not illustrated):*
**Electrolytic Polisher.** This removes the surface structure of the metal by electrolysis and is ideal for single and multiphase alloys.

C **Micro-Hardness Tester** Applying loads of 1 gram to 200 gram, this is an ideal unit for the hardness testing of all small parts, including 0.0005 in. foil, fine wire, case hardened parts, etc. £280/£340.

D **Vibratory Polisher** This equipment drastically reduces man-hour costs of specimen preparation—can polish any number of specimens from 2 to 18 at one loading without attention. £175.

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# RECENT DEVELOPMENTS
## MATERIALS : PROCESSES : EQUIPMENT

### Sonotek Flame Detection

A BASICALLY new method of flame detection developed by Elcontrol, Ltd., and designated Sonotek is based on the discovery by Elcontrol engineers that flame envelopes of all types act as a " mirror " and reflect sound waves. It is believed that this is due to the difference in densities of the flame compared to the surrounding, even hot, gases. By utilising this discovery it is possible to project sound waves of high or even ultrasonic frequency and provide a reliable method of detecting whether the flame is present or not. Devices using reflection and transmission methods are under development, and the equipment can be used with normal flicker circuitry of the well-known Elcontrol type together with printed circuit modules.

The Sonotek equipment is unaffected by oil and other mists, and any reflection from solid surfaces is completely ignored, since the final relay circuit responds only to the modulation of the carrier and even the " steadiest " of flames give a considerable amount of flicker, while solid components in the reflected path give none.

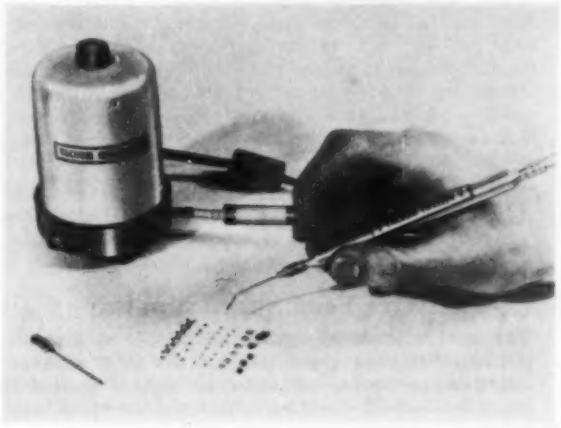
The device is completely insensitive to radiation, flickering or direct, whatever the wavelength, and is unaffected by electric sparks. It is also quite insensitive to noise, whether from flames or from furnace auxiliaries. No electrode of any type is in contact with the flame. It can be used to pinpoint the position of a flame envelope accurately, and is in effect a type of " echo sounder " for detecting a flame envelope. However rugged or smooth a flame envelope appears a flickering sonic echo is produced. The device is, of course, quite different from the previously used " acoustic " method, which detected the actual flame noise which can, of course, be greatly obscured by other noises.

The phenomenon of reflection of sound waves from a flame envelope has not been noted before, and is believed to be a basically new contribution to the art of flame detection. All aspects of the system as applied to flame detection are covered by a series of Elcontrol patents pending. The company is now exploring its applications in many fields as a supplement to their existing wide range of flame detection units. It should be emphasised that Elcontrol do not regard it as universal panacea for flame detection but it will, it is believed, take its place alongside existing methods for certain difficult applications.

*Elcontrol, Ltd., Wilbury Way, Hitchin, Herts.*

### Vacuum Tweezer System

L. E. SIMMONDS, LTD., makers of relays and control gear, have been appointed sole concessionaires in the United Kingdom for vacuum tweezer system V-100 made by The Vacuum Tweezer Co., New Jersey, U.S.A. The system, which is portable and self-contained, operates from A.C. mains supply and consists of a patented electro-magnetic vacuum generator and a vacuum pencil with stainless steel pick-up tip. No larger than a tea cup, the generator is provided with an adjustable pressure control. The vacuum pencil is similar in size to a propelling pencil, and is connected to the generator by flexible tubing which incorporates a dirt filter. Various shapes and sizes of pick-up tip are provided.



Operation is easier, and less likely to damage the component being picked up, than any mechanical handling arrangement. To hold a component the operator simply touches its surface with the pick-up tip of the pencil, at the same time covering a small opening in the pencil body to maintain vacuum. Uncovering the opening will release the pressure and the component.

The system ensures faster handling of even the most delicate parts without damage, and is ideal for instrument, electronic, laboratory and production use. As a point of interest, the first vacuum tweezers sold in the United Kingdom went to the Forensic Science Laboratory at New Scotland Yard—after only one demonstration !

*L. E. Simmonds, Ltd., 5, Byron Road, Harrow, Middlesex.*

### Diadem Emerald Electrode

AN improved Diadem Emerald electrode for use either as a contact or free arc electrode has been produced by Cooper and Turner, Ltd., for general purpose welding on all thicknesses of mild steel from 14 s.w.g. upwards. The lighter gauges of this electrode may be used in all positions. Characteristics claimed for this electrode include the production of fillet welds of mitre profile, a self-releasing slag, a wide current range, a stable soft arc, and a high burn-off rate at normal currents.

The Emerald electrode is approved by the Ministry of Transport and Lloyds Register for welding in the down-hand position on structures of primary importance and by the Admiralty and Ministry of Aviation E.I.D. for welding mild steel in the flat position. It complies with the requirements of B.S.639, B.S.1856, B.S.2642 and B.S.968 (Type A). It is coded E.947 on the B.S. 1719—1951 coding and E. 6012 on the A.W.S.—A.S.T.M. designation. Mechanical properties of deposited metal include a yield point of 24–28 tons/sq. in. and an ultimate tensile strength of 29–34 tons/sq. in. Its elongation on

1·5 in. gauge length is 26–32%, the reduction of area on 0·424 in. diameter 40–50%, and the Charpy impact value 40–60 ft./lb. A chemical analysis of the weld metal gives carbon 0·08–0·10%, silicon 0·11–0·14%, manganese 0·55–0·65%, sulphur 0·025–0·035% and phosphorus 0·015–0·025%.

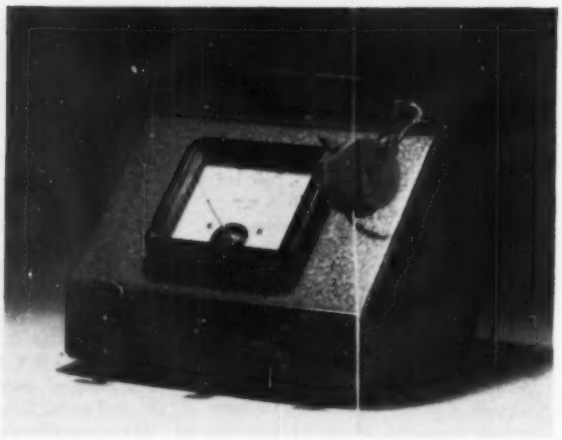
This new electrode is produced in a range of seven sizes from 12 gauge to $\frac{5}{16}$ in. diameter. The deposition time per foot of electrode at maximum current ranges from 55 sec. at 12 gauge to 72 sec. at 6 gauge. Current values are 80 A. average and 100 A. maximum at 12 gauge and 195 A. average and 235 A. maximum at 6 gauge. The weight of electrode required to deposit 100 ft. of fillet weld ranges from 7 lb. when the leg length is $\frac{1}{8}$ in. through 22 lb. at $\frac{1}{4}$ in. to 74 lb. at $\frac{1}{2}$ in.

*Cooper & Turner, Ltd., Vulcan Works, Vulcan Road, Sheffield, 9.*

## Wire Feed Speed Monitor

THE need to measure accurately the rate at which wire is being fed to a given point exists in a number of industrial processes. A particular case is that of consumable electrode welding where the electrode wire is fed from a spool into the weld zone and the rate of feed has a critical influence upon the quality of the joint produced. The usual method of determining wire feed speed is by direct tachometer reference to the speed of the drive rolls, but this is susceptible to innacuracy as the result of wire slip. The British Welding Research Association has developed and constructed a monitoring instrument which is independent of the feed rolls and which produces a signal capable of reproduction either on an oscilloscope or as a direct " inches per minute " meter reading.

In the new instrument the wire itself is made to drive a milled spindle to the end of which is attached a disc having regularly spaced slots around its periphery. The disc, in turn, is positioned between a small lamp and a photoelectric cell. As the disc rotates the light beam is interrupted and the electrical resistance of the cell alternates accordingly, the cycles taking place 72 times with each revolution of the driving spindle. The change in electrical resistance, applied to a transistorised amplifying circuit, produces a square wave output signal which is fed into an electronic frequency meter coupled to a direct reading " inches per minute " scale. For maximum accuracy the instrument is calibrated for 0–30, 0–300, 0–600 in./min., the entire scale being used in each range which is selected by means of a switch.



The monitoring head itself measures 3 in. in diameter by 1 in. deep and is small enough to be incorporated into the drive roll housing of many commercially available wire feed units. It will handle wire up to $\frac{1}{8}$ in. diameter. An additional use for the instrument is in measuring traversing or rotating table speeds in mechanised welding operations.

*British Welding Research Association, Abington Hall Cambridge.*

## Scrap Processing Machinery

SHEPPARD & SONS, LTD., heavy precision engineers, of Bridgend, Glamorgan, have introduced the Scrapmaster range of hydraulically-operated shears and baling presses for scrap processing. Scrapmaster equipment has been developed by Harris Foundry and Machine Company of Cordele, Georgia, U.S.A., with whom Sheppard & Sons, Ltd., have entered into a sole manufacturing and sales licensing agreement for the United Kingdom, Europe and elsewhere.

The equipment is characterised by rugged and essentially functional design with the accent on speed and simplicity of operation with minimum maintenance. The hydraulic scrap shear range available is continually being extended but is based on two distinct types of machine : shears with the unique baler type charging box and, alternatively, shears equipped with a compression side type charging box. The baler type charging box enables scrap to be gathered together and compressed within the box as it closes into a high density load prior to shearing into lengths which can be pre-selected, all under absolute protection. Thus scrap charges bigger than the charging box itself can be swiftly and economically processed, and this feature is common to the alternative compression side type of charging box. Coupled with these features are shearing capacities from 300 to 2,000 tons force, capable of speedy processing of the lightest to the heaviest of scrap.

Features which are common to the shear and baler range include revolutionary cellular fabricated construction and simple hydraulic operation incorporating unique, fast-operating Harris patented valves. The work of the operator is reduced to a minimum with a remote control panel providing a choice of manual push-button control, or semi-automatic or completely automatic operation.

Sheppard-Harris recently completed a 750-ton capacity hydraulic scrap shear for a Welsh scrapyard, and the successful testing of the largest baling press in the world prior to installation at a well-known steel mill.

*Sheppard & Sons, Ltd., Bridgend, Glamorgan.*

## Paint Stripper

A NEW cold immersion paint stripper for the rapid removal of the most adherent paint films, including stoved epoxy resin acrylic, alkyd amino and polyurethene enamels, by immersion and merely hosing, plunge rinsing or brushing off, has been developed by Grant & West, Ltd. Called Chemiclene No. 415, the stripper can be used in an ordinary mild-steel tank and is supplied

with its own inhibited, anti-corrosive water seal to prevent evaporation.

The fact that the new development is a cold dip means that large and small manufacturers can now install, cheaply, their own paint-stripping plant. It will cut down much of the wastage due to products being scrapped because of paintwork rejection, as all products, even those covered with the new, hard, synthetic coatings can be dealt with quickly and effectively.

Chemiclene No. 415 is said to be much safer to use than many paint strippers, but because it contains strong solvents and is mildly acidic, it is advisable for operators to wear protective clothing and eye and face shields as a protection against accidental splashing. A grade of the stripper is available which does not leave a residual smell on the metal treated.

*Grant & West, Ltd., Stoke Mill, Guildford, Surrey.*

## Differential Pressure Gauge

A DIFFERENTIAL pressure gauge with a 60 lb./sq. in. scale and a 3,000 lb./sq. in. working pressure rating has been introduced by Pall Corporation, extending the company's line of instruments for the control and measurement of pressure. The gauge has an accuracy of ± 2% and is designed for a temperature range of − 40° F. to + 200° F. Like the pressure switches and indicators in Pall's Deltadyne line, these units have no mechanical linkages. They operate by means of a magnetic coupling which eliminates the possibility of leakage. The new gauge is designed for such applications as hydraulic oils, lube oils, fuels, etc., in ground support, process and manufacturing fields. It gives a direct reading of tank levels, as well as pressure drops across filters, heat exchangers, orifices for flow metering, gas adsorbers and many other types of equipment.

*Pall Corporation, 30, Sea Cliff Avenue, Glen Cove, N.Y., U.S.A.*

## High Throughput Metal Spraying Pistol

THE Model 61 metal spraying pistol has been developed by the coating division of F. W. Berk & Co., Ltd., for an hourly throughput of 110 lb. of zinc at a deposition efficiency previously only achieved with low throughput guns : this throughput enables an area of approximately 450 sq. ft. to be given a 0·004 in. thick zinc coating at a cost, including oxygen, propane, powder and labour, of about 4d./sq. ft. This throughput is achieved by splitting the powder stream into four equal small streams and alternating these with gas streams. The gun weighs only 3 lb., and the gas, air and powder hoses all enter at the rear, thus giving good balance.

Since this gun does not require to be as versatile in spraying all types of metals at all speeds with various gases as with the conventional gun, the only control on the Model 61 gun is a spring-loaded trigger operating remote valve controls for gas and air supplies. Powder for the gun is fed from an easily recharged 2 cwt. capacity container, and the powder supply is cut off at the feeder when the trigger is released. As the powder feed unit is of fixed type, the operator is sure to work at the correct throughput in relation to the flame. A small box contains the controls, preset on final testing before despatch from the factory, and when first beginning to spray it is only necessary to open one cock and the compressed air

supply is fed to the various air-operated valves ensuring that the correct volume, pressure and time sequence of air, gas, oxygen and powder is applied to the pistol.

The fact that the powder is split into four individual streams, each surrounded by a gas flame, means that the gases have only to heat a relatively small powder cross-section in each stream : as a result, less oxygen (only 95 cu. ft./hr.) and less propane (only 27 cu. ft./hr.) is used than with equipment giving a quarter of the output of the Model 61 gun. The gun's high throughput will in most cases allow the number of guns employed in existing installations to be halved. The coatings produced with this pistol are as fine and dense as those produced by a low-output gun, and are claimed to be superior to those from any other relatively high output equipment. These coatings are ideally suited for the efficient and economic application of subsequent paint coatings if required.

*F. W. Berk & Co., Ltd., Coating Division, Brent Crescent, North Circular Road, London, N.W.10.*

## Atmospheric-Pollution Recorder

ISOKINETIC sampling apparatus designed to provide accurate and expeditious recording of dust, grit and fume emission from factory and other stacks has been successfully developed by Visco, Ltd. Marketed under the name V.I.S.A. (Visco Isokinetic Sampling Apparatus), the equipment is a production version of an advanced system based on principles issuing from recent investigations by the British Iron and Steel Research Association into atmospheric pollution : a subject now assuming increasing importance as more and more areas are scheduled as smokeless zones. At the same time, present high fuel costs demand increasing efficiency in process control to which this apparatus is calculated to make a significant contribution, for by measuring the flow rates and temperatures of gases it thereby indicates the presence of air leaks resulting in wastage of heat and fuel.

V.I.S.A. consists essentially of five linked units—sampling probe, filter unit, cooling coil, pump unit and instrument unit. In addition, a combined pitot tube and pyrometer is provided for measuring gas velocities and temperature. The sampling probe, made of stainless steel, faces directly into the stream of dusty gas and a sample is withdrawn isokinetically, i.e., it flows into the nozzle in the same direction and with the same velocity as the local undisturbed gas stream so that the dust content of the sample accurately represents that of the main gas stream at that point. The sample is then

drawn through a filter of predetermined weight and cooled to ensure that corrosive liquids are not condensed in the sampling train. A gas-tight vane pump, equipped with a by-pass valve, then expels the filtered and cooled gas sample through a gas flow-rate indicator and an integrating meter. The filter is then re-weighed, and the concentration is obtained by dividing this mass by the volume of the gas sample.

In order to sample isokinetically, the gas velocity and temperature in the stack are measured with the combined pitot tube and pyrometer and indicated on the inclined gauge and millivoltmeter. Simple two-column tables are then used which relate this gauge reading to the isokinetic sampling rate, which is maintained by operating a by-pass valve. This simple method of flow-rate control is made possible by placing the meters after the pump, where gas pressures and temperatures are virtually constant.

One of the advantages claimed for V.I.S.A. is the speed at which samples can be taken. For example, the filter may be easily changed within 30 seconds. Another attractive feature is the ease with which it can be used in confined spaces.

*Visco, Ltd., Stafford Road, Croydon, Surrey.*

## Improved High Speed Steel

FIRTH BROWN Speedicut Vanleda is an improved high speed steel containing 5% vanadium and cobalt. A high proportion of the vanadium is present as vanadium carbide, which confers high abrasion resisting properties with little or no loss of toughness. Many of the problems in machining under present day conditions have been solved by the use of sintered carbide, but there are many occasions when carbide tips are unsuitable because of lack of rigidity, or because the design of the tool is unfavourable. On such occasions Speedicut Vanleda has proved particularly valuable. Very good results have been obtained when machining difficult materials such as heat resisting steels and alloys, but worthwhile improvements have also been obtained with low alloy steels and chilled iron. Speedicut Vanleda can be used for turning, milling, drilling, boring or shaping, and, as compared with 18% tungsten or cobalt high speed steel, has been found to give longer tool life with increased output between regrinds. Higher speeds and increased feeds to cut down machining times have also proved possible. Because of the improved wear resistance a very good finish can be obtained and it has been found easier to maintain accuracy of the machined components.

*Firth Brown Tools, Ltd., Atlas Works, Sheffield 4.*

## Portable Oxygen Cutter

THE PUG—a portable lightweight oxygen cutting machine—is now being marketed by British Oxygen at a price of under £40. It weighs only 21 lb. and cuts and bevels steel up to 2 in. thick. Running on inexpensive light alloy track, the machine can make a straight cut of any length. Circles, from 3 to 45 in. in diameter, can be cut with the use of an adjustable trammel attachment. The cutter can be moved through angles up to 45° for bevelling and can be adjusted vertically and laterally. Power is supplied by a universal electric motor suitable for A.C. or D.C. at voltages of 220/240 or 110, and with a maximum consumption of 80 W. This gives a speed range of 7·3 to 36 in./min. Speed control is by rotary-type resistance. The nozzle-mixing blowpipe—for trouble-free and safer cutting—uses acetylene or propane as fuel gas. Another feature is a wrap-around handle for easy carrying and protection. The outcome of intensive design studies and exhaustive field tests, the Pug makes high quality mechanical oxygen cutting available to an ever widening range of industries.

*The British Oxygen Co., Ltd., Bridgewater House, St. James's, London, S.W.1.*

## Narrow-gap Wiredrawing Capstan

THE Marshall Richards Machine Co., Ltd., have been granted a licence to manufacture on a commercial basis the narrow-gap capstan developed in the course of recent research at the British Iron and Steel Research Association's Sheffield Laboratories. Any increase in the maximum speeds and outputs of machines drawing high tensile wire must be accompanied by a corresponding improvement in the cooling efficiency if the loss in ductility which results from drawing at elevated temperatures is to be avoided. Improved air blast cooling is not an economic proposition, but alterations to the water cooling system can result in significant improvements.

Speed increases of some 30% can be achieved by preventing rust formation on the inner surfaces of the capstan, by electroplating or water treatment. Further improvements in output may be obtained by retaining these features and by incorporating the narrow-gap capstan. Here the cooling water is passed through a narrow channel between the drawing ring and a stationary inner cylinder. This ensures the water flow is turbulent and brings about efficient heat transfer. During pilot plant trials it proved possible to achieve a 40% increase in the production rates of heavy gauge wire, with a corresponding increase of 20% for the finer gauges.

This design can be fitted to most existing machines with relatively little modification. It can of course be used on mills where a greater output is not required, resulting in a reduced water consumption, and in improved working conditions where the external air blast can be eliminated.

*Marshall Richards Machine Co., Ltd., Crook, Co. Durham.*

## Pressurised Coolant Clarifier

A NEW pressurised coolant clarifier has been added to the Philips range of machine tool coolant filtration equipment marketed by Research & Control Instruments, Ltd. A specially developed inlet system has been incorporated into this new unit which ensures that the filter medium is kept clear until the filter is full. A further claim is that the clarifier cannot overflow, and that consequently no visual alarm is necessary. A high degree of filtration on both ferrous and non-ferrous work is carried out by the new unit, and the special filter replacement elements cost only £1 each. The sludge capacity is 10 gal., or 2 cwt., ensuring long machine runs before cleaning is needed. One $\frac{3}{4}$ h.p. pump is incorporated in the equipment and this eliminates the usual machine tool pump, and gives a flow rate of 30 gal./min. The floor space required, with the standard 50 gal. tank is 2 ft. 6 in. × 4 ft. 9 in., and the only connections are mains supply and a flexible hose to the coolant delivery outlet.

*Research & Control Instruments, Ltd., Instrument House, 207, King's Cross Road, London, W.C.1.*

8 GOOD REASONS WHY LEADING INDUSTRIES USE

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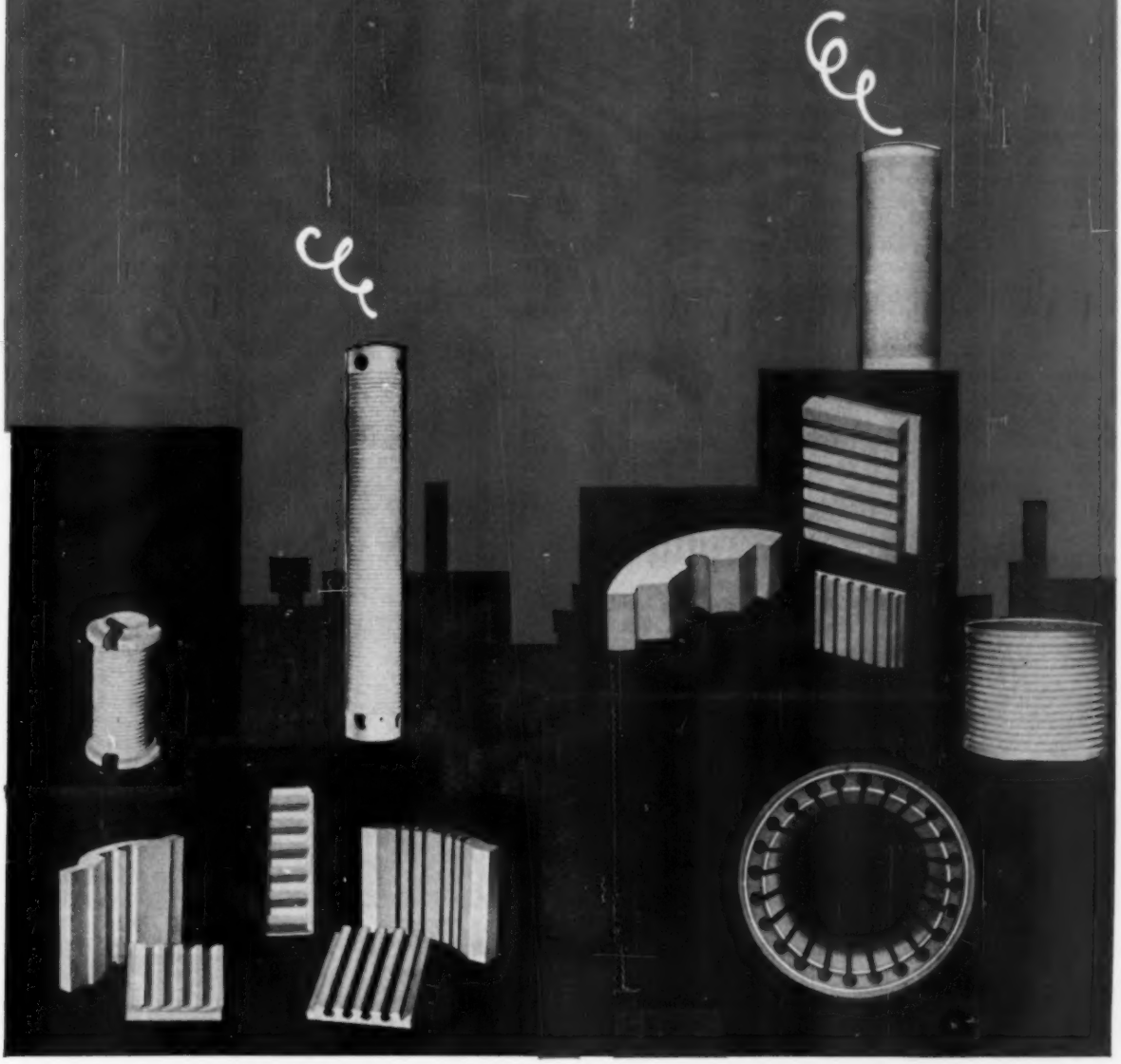

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# CURRENT LITERATURE

## Book Notice

### ALUMINIUM BRIGHT TRIM

A.D.A. Application Brochure No. 15. 40 pp., numerous illustrations. Published by the Aluminium Development Association, 33 Grosvenor Street, London, W.1. 10s. 6d.

THIS latest in the series of application brochures published by the Aluminium Development Association is primarily addressed to manufacturers of finished products and accessories having trim items, but also provides information for installation contractors, distributors and agents. Whilst there are numerous illustrations from the road transport world to illustrate aluminium bright trim, the brochure may surprise many readers with the information it contains concerning applications to other fields such as domestic equipment, shop fronts, radio and recording equipment and costume jewellery. The illustrations merely indicate what has been done so far in a continually expanding use both of aluminium and of the brightening processes described. Its publication is particularly well timed since it coincides closely with the Association's Conference on Anodising held at the University of Nottingham in September last when a considerable step forward was taken in the needed closer co-operation between the anodisers, the aluminium producing and fabricating industries, and the users, and it is of added interest that the brochure can be used as the basis of a specification covering materials especially designed for bright trim application.

The book opens with a general statement about aluminium bright trim and the aluminium-base materials best suited for the purpose, and in this section and others it takes into account the 1961 revised edition of B.S. 1615 "Anodic Oxidation Coatings on Aluminium." Subsequent sections give information and advice on fabrication and installation, and there is a brief section concerning the brightening and anodising processes with references to other sources of information on this specialised subject.

Notes on design characteristics refer to an appendix which gives data on mechanical properties of the various bright trim alloys, and following this come notes on the handling, storing and transportation of highly reflective metallic surfaces, and on the behaviour of aluminium bright trim under weathering. Another appendix describes appropriate quality control and test methods.

## Trade Publications

THE August issue of *Efco Journal* contains the conclusion of an article on the use of high frequency induction equipment in production heat treatment, dealing with surface hardening applications and some special applications of H.F. heating. There is also a report from British United Shoe Machinery Co., Ltd., on the use of an Efco-automatic multi-purpose closed-quench furnace; an article on fuel-fired furnaces for heating prior to hot forming; and a description of the Novexor rotary filing machine.

THE ultrasonic cleaning principle incorporated in the Pall-Cavitron HIPS ultrasonic cleaner is discussed in an article available from Aircraft Porous Media, Inc., Glen Cove, New York. The article, entitled "Focused Energy Cleans Filters," describes how focused ultrasonic energy, combined with the test facilities in the HIPS unit, reliably cleans and tests fine wire mesh filter elements used in aircraft, missiles and ground support equipment as well as valves, fittings and industrial components.

THE latest series of data sheets issued by Johnson, Matthey & Co., Ltd., covers their range of high purity metals. In recent years, the rapid advance of technical developments in many fields has brought about a demand for a wider variety of high purity metals and a greater diversity of physical forms. Johnson Matthey have investigated and perfected techniques for producing an extensive range of high purity metals and for fabricating many of them into rod, sheet and other forms. In the data sheets, information is given on thirty-eight metals, including noble, rare earth and certain base and rarer metals. The general properties of each element are tabulated and details are given of the forms in current production. In most cases the metals are available in more than one grade, the metallic impurity contents being expressed in parts per million. The data sheets are freely available on request to the company's head office at 73-83 Hatton Garden, London, E.C.1.

KIRCALDY and linoleum are almost synonymous and, whilst it has no direct metallurgical content, an article on the growth of the Nairn group in the September, 1961 issue of *Finishing Facts* makes interesting reading. Of more direct interest to readers of METALLURGIA are the application of finishes to metal surfaces in the manufacture of lathes, mopeds, dumper trucks, and aircraft. The issue also contains a feature on the new laboratory building of the I.C.I. paints division, by whom *Finishing Facts* is published.

"LEAD Cable Sheathing—Alloy Characteristics and Applications," the second publication in the series issued by the Lead Development Association, is designed to stimulate interest in the use of lead in cable sheathing. Both lead and lead alloys possess the basic requirements of a cable sheath—impermeability to moisture and good corrosion resistance. For certain cable construction and conditions of installation, however, it is essential to employ a lead alloy to meet special needs. This booklet describes these special requirements and explains how they may be met by selection from the lead sheathing alloys commonly available in the U.K. An information sheet for each lead alloy is included in the booklet, giving full details of composition, characteristics and the type of cable and installations for which the alloy is suitable. This publication will appeal particularly to technologists concerned with the use of cables but will also be of great value to the cable manufacturer.

LATEST addition to the series of E.M.I. machine tool position control systems is the Emicon B100. Employing the well proven analogue system of measurement, the B100 has a positional accuracy of ±0·002 in. With such accuracy and the use of fully automatic head cycling, the system shows considerable economic saving. The B100 control system is capable of controlling machine movements driven by electric or hydraulic servo systems,

Ward Leonard controls, or A.C. motors with clutches. Position feed-back may be from Emicon inductors, leadscrews, or racks and pinions. Facilities for 5- or 8-channel tape, tape spooling, line milling control, and/or turret store are available. Complete technical specification is given in a new leaflet published by E.M.I. Electronics, Ltd., which also gives details of the types of tapes and teleprinters used with the B100 and outlines programming facilities. Copies of this leaflet may be obtained from Industrial Division, E.M.I. Electronics, Ltd., Hayes, Middlesex.

A NEW 60-page booklet entitled, "The Role of Molybdenum and Copper in Corrosion Resistant Steels and Alloys," has been published by Climax Molybdenum Company, a division of American Metal Climax, Inc., 1270 Avenue of the America's, New York 20, New York, U.S.A. Containing numerous tables, charts, graphs and photographs, the new booklet describes in detail the rapid development during the 1950's of corrosion resistant steels based on the use of molybdenum, copper and nickel, together with sufficient chromium to retain, in large measure, the resistance to oxidation provided in the familiar chromium and the austenitic chromium-nickel (18–8) types of stainless steel. The new booklet begins with the corrosion resisting properties of the constituent metallic elements themselves, and proceeds to show how investigators have put these elements together in various combinations to achieve specific degrees of corrosion resistance in the resultant alloys. Special emphasis is placed on the economic and technological benefits of selecting the proper alloy for the specific performance required.

THAT minds matter as much as machines in the training of young engineers is one of the points emphasised in an article on apprentice training which appears in the October/December edition of *The Forge*, quarterly journal of the Brockhouse organisation. The issue also contains an illustrated feature on the new mechanised moulding plant installed at one of the group's Midland foundries, and gives details of a new and revolutionary motor car breakdown recovery unit, developed by another subsidiary company. Other features include a pictorial survey of some of the varied industrial and commercial establishments using oil-fired heating, and reports of group activities at home and abroad.

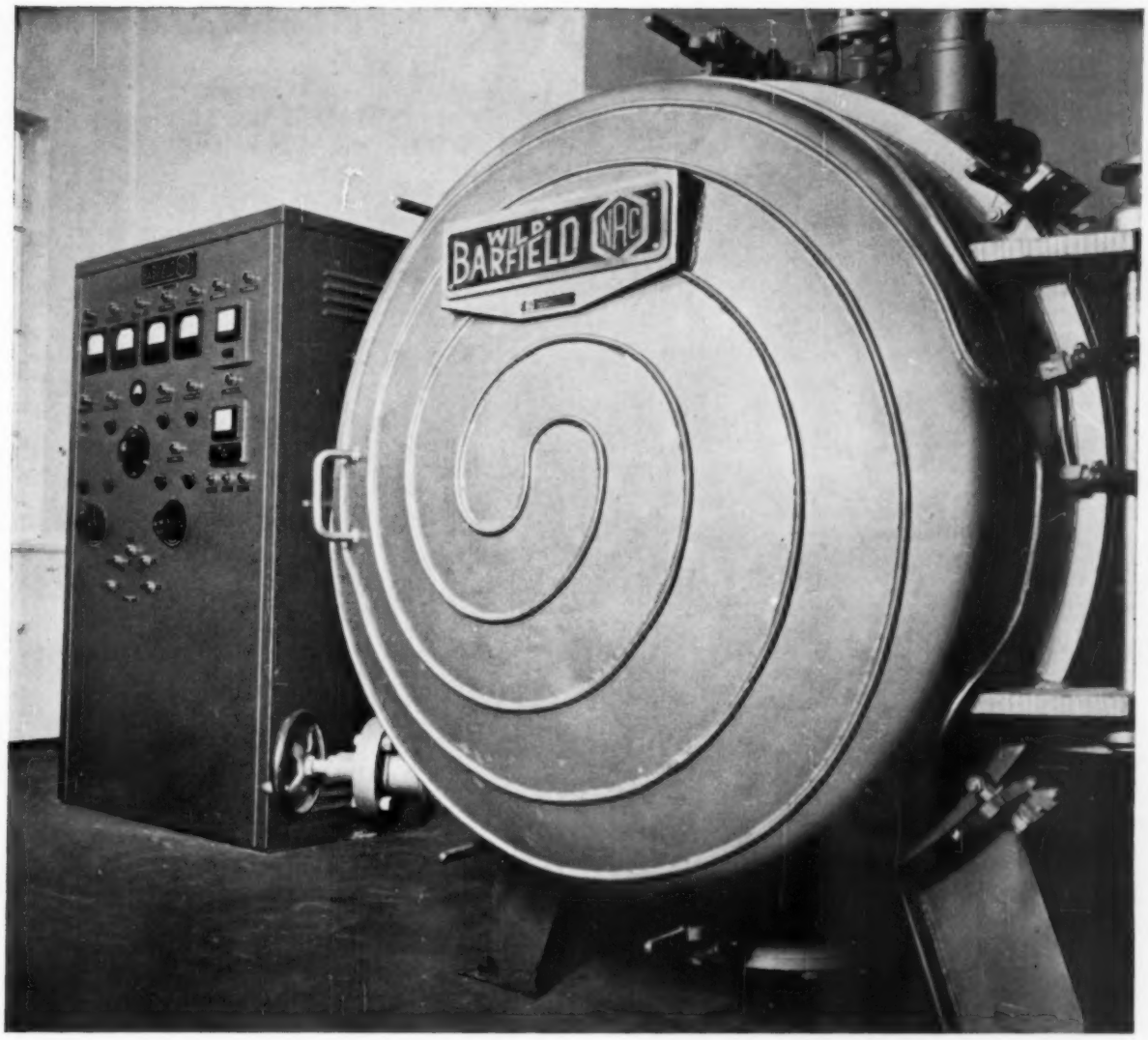
THE fifth issue of *Die Casting News*, published by the Zinc Alloy Die Casters' Association, 34 Berkeley Square, London, W.1, states that about 64,000 tons of zinc for die casting were consumed in 1960 and, although motor cars still provide by far the largest outlet for the castings, the examples quoted in this issue show the increasing use of pressure die casting in other fields. The products illustrated include die cast components for high fidelity equipment, including loudspeaker chassis and turntables, as well as examples of castings used in a selection of familiar mass-produced domestic appliances—the Cona coffee machine, the Horstmann gas lighter, and Shepherd castors. More specialised uses are also shown in data processing machines and pressure gauges. This bulletin, like previous issues, is distributed widely to designers and production engineers, to whom the design possibilities and production advantages of the die casting process should be of particular value.

THE July/August issue of *The Nickel Bulletin* contains more than a hundred abstracts of recent technical and patent literature. The section concerned with nickel-containing heat- and corrosion-resisting materials is, as usual, the most extensive of the issue. Of the literature abstracted in this category, particular attention may be directed to papers reporting corrosion experience with pulp-mill equipment and work on the microstructural and high-temperature characteristics of nickel-base alloys. Other items in this section relate to analytical techniques, reviews of recent developments in heat- and corrosion-resisting materials, the influence of copper and boron on the properties of austenitic steels, and investigations carried out to evaluate weldability and resistance to various corrosive media. Literature on nickel plating has been given due consideration, and reference is made to several important papers on the corrosion behaviour of nickel-chromium electrodeposited coatings. In the nickel section attention is drawn, *inter alia*, to the effects of nickel derivatives on the resistance of rubber to atmospheric agents, and items pertaining to the properties of non-ferrous alloys are followed by sections on nickel-iron magnetic alloys and nickel-containing cast irons and structural steels. The patent abstracts range in subject matter from cathode alloys and one-coat enamelling to nickel plating, glass-to-metal sealing alloys, and nickel-containing heat- and corrosion-resisting alloys and steels.

A NEW 8-page brochure recently issued by Shandon Scientific Co., Ltd., covers a complete range of metallographic equipment made by the well-known U.S. firm of Buehler, Ltd., for whom Shandon are the U.K. distributors. All stages in specimen preparation are catered for, from the initial cutting-off of a specimen, through the mounting under controlled conditions of temperature and pressure, to the final grinding and polishing preparatory to microscopic examination. Shandon hold stocks of the various items of equipment, as well as mounting materials for the presses and a wide range of grinding and polishing materials, including abrasive papers, polishing cloths, diamond compound and alumina.

THE front of a new illustrated brochure states: "Wellman steelworks plants and equipment cover the world." It is not surprising therefore to find within illustrations in colour of installations in India, Australia, South Africa, Spain and France. The extent to which The Wellman Smith Owen Engineering Corporation, Ltd., is engaged in the manufacture of steelworks equipment is shown more clearly, however, in the rest of the booklet dealing with installations in the United Kingdom of open hearth furnaces, charging machines, ladle cranes, special-purpose cranes, reheating furnaces, ingot strippers, rolling mills and auxiliaries, etc. The company's interest in oxygen steelmaking processes is also reflected in the pages of this brochure.

IN Efco-Lindberg Cyclone furnaces the air is heated in a separate chamber away from the charge, which is thus removed from the field of direct radiation. A new publication issued by Efco Furnaces, Ltd., illustrates a number of typical applications of both gas-fired and electrically-heated Cyclone furnaces of vertical and horizontal types. Such furnaces are suitable for operation at temperatures up to 700° C. For high temperatures—up to 950° C.—there are the Super Cyclone furnaces: in the electric type the elements are contained in the works chamber but separated from the charge by a baffle to prevent direct radiation.

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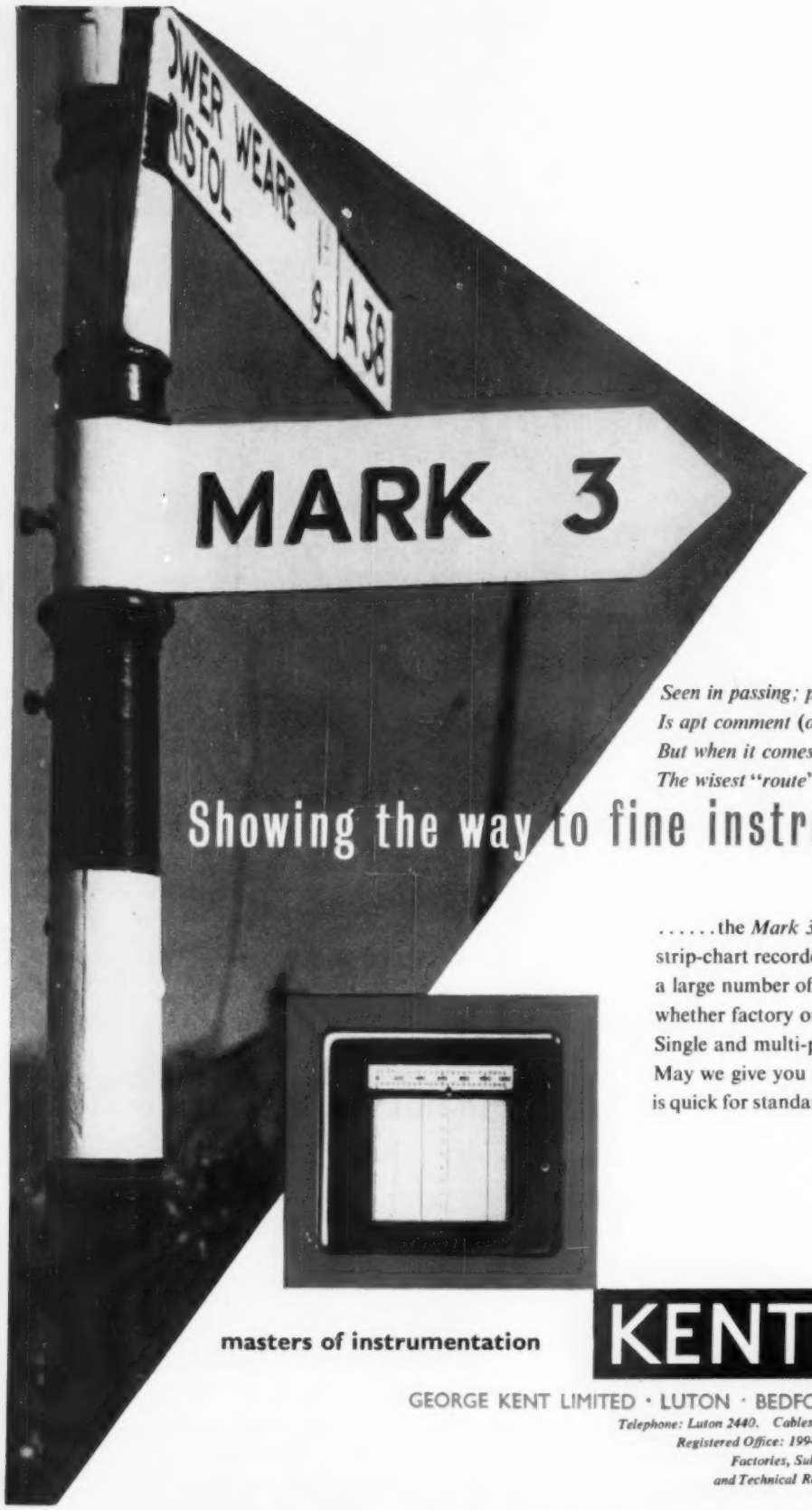


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LABORATORY METHODS
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# Creep Testing at United Steel Companies Limited

By J. D. Murray,* A.Met., A.I.M. and J. Hacon,† A.Met., A.I.M.

*An organisation engaged in the development of materials for high temperature service has to carry out a variety of test programmes of both creep and stress-to-rupture types. An account is given of the combination of large batteries of single-point high-accuracy creep machines, single-point stress-to-rupture machines, and multi-specimen creep and/or stress-to-rupture machines available at United Steel's Swinden Laboratories. The major part of the article is devoted to a detailed description of the construction and testing of the recently developed Unisteel multi-specimen testing machine.*

THE phenomenon of creep became of practical importance to steel makers when power plant design engineers first considered steam temperatures in excess of 350° C. in conventional power stations. From this start there was a steady increase of interest in the subject, and also in the research effort expended upon it, up to the outbreak of the Second World War. At this stage the development of the gas turbine engine was accelerated and this, in turn, meant that a greater study of creep in steel was required. The post-war years have seen a further development of the gas turbine, renewed interest in conventional power plant and the development of nuclear power stations.

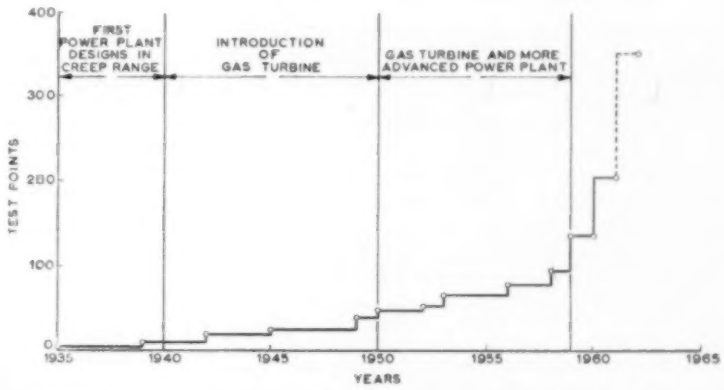


**Fig. 1.—Increase in creep testing facilities since 1945 in the Laboratory of The United Steel Cos., Ltd.**

In the United Steel Companies the first experiments aimed at evaluating the properties of different steels were carried out in 1932. This work was done with the Barr-Bardgett apparatus which classified the steels on the basis of a 48 hour test. As experience was gained the need for longer-term testing was recognised, and in 1937 what is now regarded as the more conventional creep equipment was installed. The gradual expansion in test facilities of this latter type, which took place up to 1959, is illustrated in Fig. 1. Also shown are the principal engineering developments that occurred, these providing the main reason for the expansion. By 1958–59 it became clear that a further large scale expansion was required in order to establish accurately the long-term properties of many creep steels then available, and also to keep pace with the increased research effort required to produce the new materials needed to meet the increasingly severe conditions of modern high-efficiency, high-temperature plant. Estimates indicated that at least a threefold increase in test facilities was needed. In view of this, it was clear that new apparatus was required that was more economical in terms of initial capital costs, running costs (in terms of man-hours to operate) and floor space. Consideration was therefore given to the design of a machine that could achieve these economies, and from this consideration the Unisteel multi-specimen creep machine was developed. The machine will be described in detail in this article, but before doing so the main features of the older type of equipment will be outlined.

## Details of Existing Equipment

### 5 ton Machines

The first conventional creep equipment to be installed was that based on the N.P.L. design for a 5 ton machine. In 1937 no commercial machines were available on the British market, and consequently the apparatus was "home-made." At a later date the 5 ton machine was manufactured by S. Denison (Leeds), Ltd., and a battery of these latter machines in service in Swinden Laboratories is shown in Fig. 2. A total of thirty machines of this type was installed and these are used for high sensitivity creep testing, i.e. the measurement of up to 1% total plastic strain. A Martens mirror type

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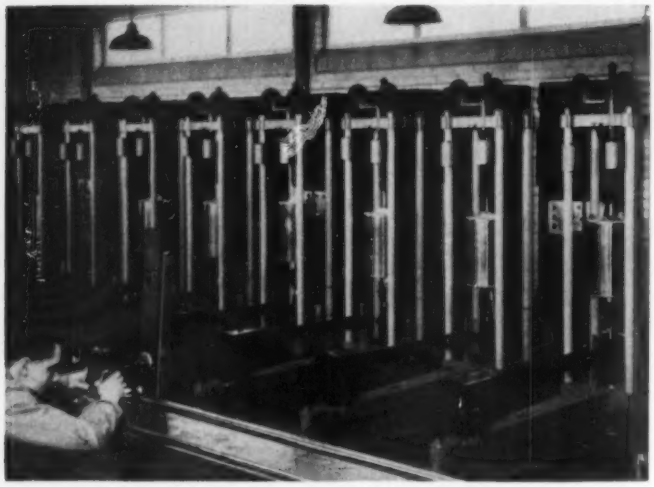


**Fig. 2.—A battery of 5 ton creep machines.**

extensometer is used with each machine, and with a 5 in. gauge length and the optical magnification employed a strain measurement of as little as $2 \times 10^{-}$ can be achieved. Each machine requires a floor area of approximately 21 sq. ft. whilst the " mirror to scale distance " is 12 ft.

### 2 ton Machines

By 1946 it had become clear that a further type of creep testing machine was required that could do both creep testing, but at a lower degree of accuracy than the 5 ton machine, and also rupture testing. Consequently machines based on the N.P.L. 2 ton machine were installed. These were again " home-made " and over a period of time eighteen of them were installed. In 1957, because of the need for more rupture testing, twelve of these machines were modified to test two specimens at one time. When used for creep testing the extensometer employed was of the dial gauge type. The machines were constructed in groups of three or six, and groups of three occupied a floor area of 16 sq. ft.

### ¾ ton Denison Machines

From 1946 onwards, as the need for more rupture testing became apparent, the ¾ ton (T47 Denison) machines were installed : by 1955 forty of them were in use. These machines are small and compact and test a small specimen, which is a distinct advantage when alloy development work is being carried out and only small quantities of experimental steels are available. They can be mounted separately, in which case they occupy a floor area of 5 sq. ft., or more closely packed on benches, which brings down the floor area considerably. Their main disadvantages are their limited capacity, small specimen size, and poorer temperature control compared with the larger units.

For a brief period from 1958 to the early part of 1960 additional rupture capacity was obtained by modifying the old Barr-Bardgett equipment : since this was only a temporary measure no details of this equipment will be given.

## Development of New Equipment

As already indicated, it became clear by the end of 1958 that a large expansion in the creep testing facilities was required. To meet this requirement at a reasonable cost and within the limits of the floor space available, it was necessary to adopt multi-specimen testing procedures. Since there was no suitable commercial equipment available at that time which met our needs, it was decided to design a new testing machine. The multi-specimen machines then available tested a single string of some ten specimens, and it was considered that such machines lacked versatility, since only one stress level was obtained with each machine unless specimens of different diameters were used. Also, they were more difficult to programme efficiently in laboratories with a wide range of different materials under investigation at the same time.

The aim was, therefore, to produce a machine which would be more versatile in its operation and yet meet our additional demands for both stress-to-rupture and creep testing capacity. A machine was subsequently designed and produced which would take up to twelve stress-to-rupture specimens at one time, in four strings each of three specimens, or four creep tests complete with extensometers. By this method four stress levels would be obtained without having to resort to changes in specimen geometry.

This arrangement makes it possible to carry out elevated temperature testing in accordance with the relevant British Standard Specification as follows :—

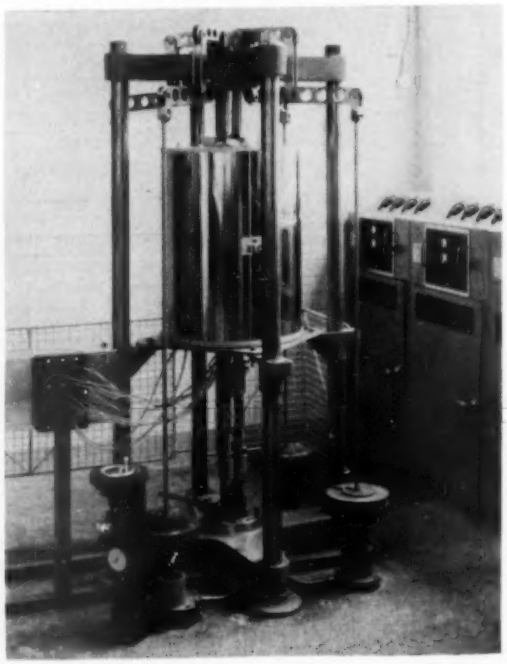


**Fig. 3.—Unisteel multi-specimen creep testing machine.**

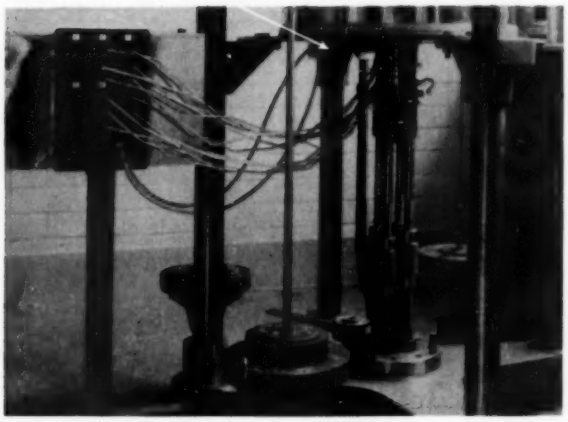


**Fig. 4.—Ratchet mechanism with spanner in position and resistance thermometer indicated by arrow.**

(*a*) Stress-to-rupture testing—British Standard 3082, Part 2, 1959.

(*b*) Non-interrupted creep testing—British Standard 3082, Part 3, 1959.

(*c*) Interrupted creep testing—British Standard 3082, Part 4, 1959.

### General Construction

A general view of the machine complete with furnace is shown in Fig. 3. It will be seen that it consists of four weighing levers each capable of applying a tensile load of up to 3 tons to a string of three stress-to-rupture specimens or one creep specimen complete with extensometer. The load is applied through a double lever system operating through two knife edge pivots and four sets of ball races, and is designed to give a load-on-specimen magnification of 20 : 1. The ratio is composed of two stages of 4 : 1 and 5 : 1, and in order to correct for slight inaccuracies in manufacture the fulcrum of one of the knife edge pivots is adjustable. This adjustment is carried out during manufacture and no further adjustments have been found necessary when the machines have been installed in the laboratory.

Levelling of the beams to accommodate the extension of the specimens is carried out manually by operating, with a ratchet spanner, a screw mechanism situated at the base of the machine. This mechanism, with the spanner in its operating position, is illustrated in Fig. 4. Arrangements have also been made for the gradual application of the load to the scale pan by means of a screw jack. With this apparatus it is possible to load in increments once the screw-dial calibration has been determined. This, of course, is particularly important when using the machine for creep tests, since in this case a load extension curve is necessary.

An important feature of the machine is its compactness : it occupies a floor space of only 3 ft. 1 in. × 3 ft. 1 in. and can be arranged in rows spaced at 4 ft. centres. To illustrate this factor a scale diagram of an installation being undertaken at Swinden Laboratories involving twelve machines is shown in Fig. 5.

It will be seen from Fig. 3 that steel mesh guards can also be slotted into the furnace brackets to prevent accidental contact with the loading weights. Also in this illustration it will be noted that the machine incorporates a rubber shock absorber attached to the bottom of each scale pan. This prevents vibrations being transmitted to the remaining specimens when a fracture occurs. In the cup-shaped casting below the scale pan is situated a micro-switch which controls a time clock. When fracture occurs the loaded scale pan falls into the casting and operates the micro-switch, which in turn stops a time clock on the adjacent control panel.

### Calibration

Each machine installed to date has been calibrated using a 6 ton maximum load capacity proving ring and a 600 lb. spring balance. The proving ring is inserted into each of the four loading systems in turn and loaded in increments up to approximately 200 lb. load, and the proving ring dial gauge reading is noted at each load increment. A load *v.* dial gauge reading graph is then constructed and the dial gauge divisions for 1 lb. load are calculated. From this figure, and by knowing the calibration of the proving ring, the mechanical advantage or lever ratio can be calculated. A typical calibration graph, together with the calculation of the lever ratio, is shown in Fig. 6.

The second part of the calibration is to measure the "dead load" of the machine, this being the static load of the machine before any additional load is applied. This is measured by suspending the spring balance in each string in turn and recording the reading when the lever system is in the horizontal position. In the six machines calibrated to date the minimum "dead load" reading recorded has been 180 lb. and the maximum 182 lb.

Having calibrated the machine in the above manner, the lever ratio and the static load on the machine are

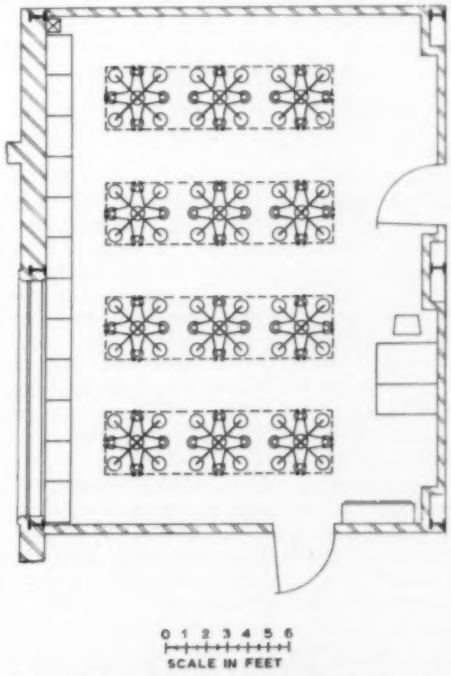
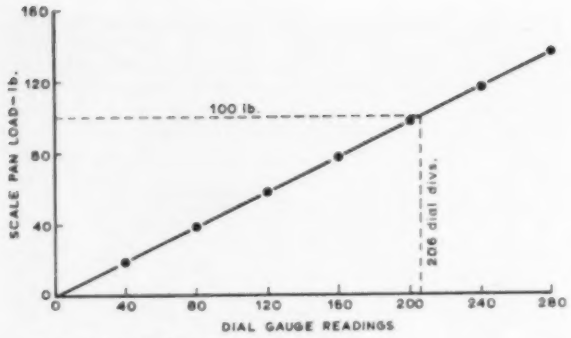



**Fig. 5.—Layout of twelve machines in Swinden Laboratories.**




*Proving Ring Calibration*

1 ton load = 230 dial divisions.

*Mechanical Advantage or Lever Ratio Calculation*

100 lb. scale pan load = 206 dial divisions
1 lb. scale pan load = 2·06 dial divisions

$$\text{Mechanical advantage or lever ratio} = \frac{2{\cdot}06 \times 2{,}240}{230}$$

$$= 20{\cdot}05 : 1$$

**Fig. 6.—Calibration and mechanical advantage calculation.**

known, and this enables the scale pan load to be calculated for any given stress on the specimen. A calibration curve can subsequently be produced for any diameter specimen, so that the load required on the scale pan for a given stress can be quickly obtained. A typical graph for 0·3 in. diameter specimens is shown in Fig. 7.

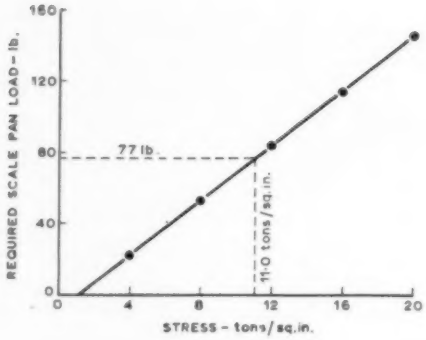
During the calibration of the machines received to date it has been seen that the calibrations are very similar and, consequently, such a graph as shown in Fig. 6 is applicable for each machine.

## Furnace Construction

A new design of furnace incorporating a central steel core has been successfully incorporated into this machine. The furnace is 19 in. in diameter and 2 ft. 1 in. long, and consists of a 6 in. diameter silica tube on to which is wound the heating element. This element is of Nichrome wire and is wound in three zones with cold resistance values of 10 ohms, 3 ohms, and 10 ohms, respectively. The insulating material between the silica tube and the outer casing is Dextramite. To complete the construction of the furnace a central steel core constructed of $\frac{1}{2}$ in. thick heat-resisting steel tube is positioned inside the silica tube. Inside this steel tube a welded cruciform insert which divides the central bore of the tube into four compartments is incorporated. Each compartment can then accommodate one string of specimens or a single specimen with extensometer attached.

The main purpose of this central steel core is to provide a large reservoir of heat in the furnace, so that when one string of specimens is removed for specimen replacement, etc., the three remaining strings do not deviate markedly from their test temperature. Two other important advantages gained by having such a construction are :—

(*i*) It assists in obtaining an even heat distribution around the specimens and thereby eliminates temperature gradient effects.




*Example*

For a specimen 0·300 in. diameter and a stress of 11·0 tons/sq. in., the required scale pan load is 77·0 lb.

**Fig. 7.—Relationship between stress (tons/sq. in.) and scale pan load for 0·300 in. diameter specimens.**

(*ii*) It prevents mechanical interference between the four strings and their extensometers when used. This is particularly important when fitting new specimens and also when fracture occurs in rupture testing.

Fitted to the top and bottom of this central steel core are refractory "end" pieces which merely reduce the heat losses at the top and bottom of the furnace. An illustration of the components which are used in the construction of the furnace is seen in Fig. 8.

A 10 in. long C.N.S. platinum resistance thermometer is located at the bottom of the furnace between the

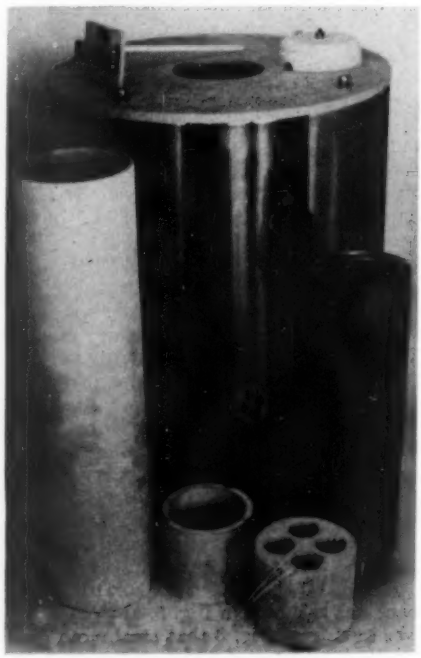


**Fig. 8.—Furnace construction components.**

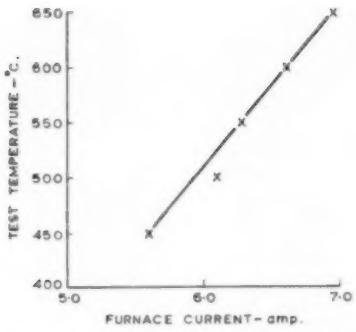



**Fig. 9.—Relationship between furnace current and test temperature.**

silica tube and the central steel core, and is therefore in close proximity to the furnace heating element. The exact location of the thermometer with respect to the bottom of the furnace is shown in Fig. 4. The reason for mounting the resistance thermometer at the bottom of the furnace is for ease of maintenance in the event of a fault occurring. A graph showing the relationship between test temperature and the furnace control current is shown in Fig. 9.

### Temperature Control Equipment

All the temperature control equipment is housed in a sheet metal cabinet occupying 2 ft. × 1 ft. 3 in. floor space. A photograph of the complete cabinet with the door removed for illustration purposes is shown in Fig. 10.

The equipment comprises four Venner time clocks, each of which is in series with a micro-switch housed in the shock absorber casting; three adjustable shunt resistances; a C.N.S. temperature controller with a 1·5 kVA. saturable reactor; an external ammeter socket with a push-button contact; and a main switch unit.

A saturable reactor temperature control unit is being used with this machine, and to date this has proved entirely satisfactory. The main advantage this method offers over the more conventional proportional type of controller is the long term stability and reliability due to the absence of any switching mechanisms. The basic principle of operation is as follows:—

A small D.C. potential termed the control current is fed into the core of a saturable reactor, which in turn develops an output potential which is fed to the furnace heating element. This D.C. potential input to the reactor is varied according to the signal received from the platinum resistance thermometer situated in the furnace between the silica tube and the central steel core.

In the initial stages of attaining a particular test temperature it is so arranged that the D.C. input potential is at a maximum value, so that maximum current is applied to the furnace elements. However, on nearing the test temperature, the D.C. control current decreases and therefore the input to the furnace decreases accordingly. This prevents any marked "over-shoot" of the test temperature and gives a more rapid "heating-up" process than with other methods of temperature control. When the test temperature is attained the D.C. control current is of the recommended order of 60–80 mA.

Another feature of the control cabinet is the provision of three shunt resistances, each of which is wired in

**Fig. 10.—Control cabinet with door removed.**

parallel with either the top, middle or bottom winding of the furnace heating element. This enables the current flowing through each winding to be controlled, so that even temperature distribution over the test pieces can be achieved quickly. An external socket is also provided for connection to a portable ammeter which enables the total circuit current to be read merely by pressing a push-button contact on the panel.

### Auxiliary Equipment

*Lifting Jack*

This is a screw-operated lifting device used for loading the machine, and as it also incorporates a graduated dial gauge, it is possible to apply the load at a particular rate so that when dealing with creep tests a load extension curve can be obtained. It will be appreciated that one lifting jack will serve a number of machines.

*Fail Safe Mechanisms*

The machine incorporates two "fail safe" devices, one being mechanically operated and the other electrically. In the event of a power failure or controller/resistance thermometer failure which resulted in the test temperature decreasing, the mechanical device shown in Figs. 11 and 12 would become operative. It can be seen in Fig. 11 (normal position) that this consists of a steel arm positioned a short distance away from a vertical pivoted linkage. When the temperature decreases the specimens contract. This contraction causes the beam carrying the steel arm to move upwards and in time it comes into contact with the vertical linkage. This causes the linkage to drop out of position as seen in Fig. 12 ("collapsed" position). As this occurs the scale pan falls into the shock absorber casting, thereby removing

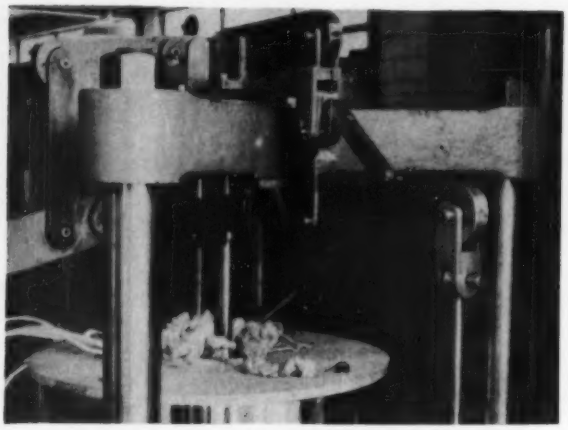


Fig. 11.—Release linkage—normal.

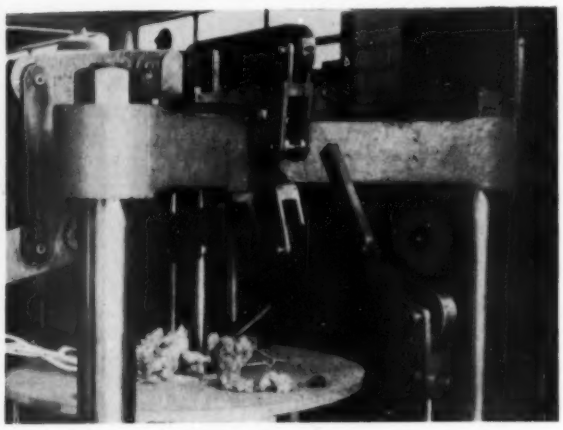


Fig. 12.—Release linkage—collapsed.

the load from the specimens and hence avoiding damage due to any " over-straining " effects.

The output value of the temperature controller is the only valve in the circuit which in the event of failure would cause the test temperature to increase. As a precaution against this occurring in practice, a " spare " output valve has been fitted into the circuit together with a monitoring meter to the front panel. In the event of a valve failure the " spare " valve is brought automatically into circuit and this is indicated by a fall of the needle into a red zone on the monitoring meter. The faulty valve can then be replaced while the controller is still operational.

*Extensometer*

The extensometer used when operating the machine as a creep testing unit is designed to accommodate a 5 in. gauge length specimen of 0·357 in. diameter. It is attached to the specimen by knife edges which are in turn secured by fixing screws. A photograph of the extensometer is shown in Fig. 13, from which it will be seen that it incorporates a 0·0001 in. increment dial gauge positioned to indicate the " mean " movement of both sides of the extensometer. The dial gauge has a maximum travel of $\frac{1}{2}$ in., which allows 10% strain to be accommodated on a 5 in. gauge length without any re-setting being required. This is adequate for most creep testing applications, but the extensometer is so designed that the gauge length can be reduced if greater amounts of strain are to be measured. With a 5 in. gauge length and reading to half a dial division, a strain accuracy of $1 \times 10^{-5}$ in./in. can be obtained.

## Operation of the Machine

When a new machine is being commissioned it is practice to instal " dummy " test-pieces and to heat these to the required test temperature. This is to confirm that the temperature gradient limits can be achieved. Once this stage has been reached the " dummy " specimens are replaced by the actual test specimens. Details of both the creep and rupture specimen being used are shown in Fig. 14.

*Assembling Specimens*

For the rupture and interrupted creep testing the first operation is to assemble the string of three specimens as shown in Fig. 15, using the split couplings which are also illustrated in this figure. The purpose of the split couplings is for ease of specimen replacement when a fracture occurs and to prevent damage to the specimens during this operation. A molybdenum disulphide base grease is also used to prevent seizing of the specimens in these couplings.

Fig. 13.—Creep dial gauge extensometer.

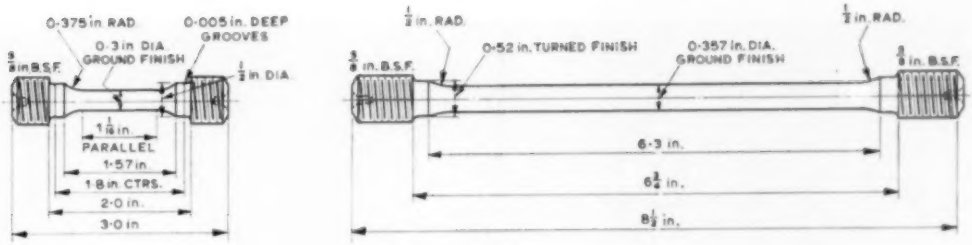



**Fig. 14.—Details of specimens.**

It will be seen in Fig. 15 that twelve thermocouples have been attached to the illustrated string to determine the temperature at positions between the three normal thermocouple positions. This temperature survey is referred to in detail later. Three thermocouples are normally attached to a string of three specimens and they would occupy the positions (numbered 2, 6 and 10) in Fig. 15. When the three thermocouples have been attached the string is ready for insertion into the furnace.

For the non-interrupted creep testing the extensometer shown in Fig. 13 is easily assembled on to the test-piece by clamping the knife edge grips on to the 5 in. gauge length and securing with a fixing screw. The gauge length is accurately located by having a " gauge bar spacer " of the required length, and the grips are simply positioned at the top and bottom of this.

When assembled, the specimen with extensometer, bottom loading bar and three thermocouples attached is brought to the machine and is ready for insertion into the furnace.

*Insertion of Specimen into the Machine*

This sequence of operations for rupture and interrupted creep testing is illustrated in Figs. 16*a*, *b* and *c*. The assembled string complete with thermocouples attached is inserted into the bottom of the furnace after first screwing into position the top loading bar (Fig. 16*a*). The string is then gradually moved into the furnace and the bottom loading bar screwed into position (Fig. 16*b*). Finally, the string is moved fully into the furnace and, whilst supported at the bottom, a pin is pushed through the top shackle and the loading bar to secure the string in position (Fig. 16*c*).

When a fracture occurs the reverse procedure is adopted, which means that the bottom loading bar is first removed from the furnace, enabling the position of the fracture to be located. If the bottom or middle specimen in the string has fractured, the top loading bar with the unbroken specimen attached is lowered through the furnace. If, however, the top specimen fractures, it is possible to remove the top loading bar through the top of the furnace.

For non-interrupted creep testing the specimen with extensometer and thermocouples attached is inserted into the furnace through the bottom and subsequently screwed into the top loading bar. The top loading bar incorporates an additional " make-up " piece, when using the machine for creep tests, which adjusts the difference in length between a string of specimens and a test-piece with extensometer attached. After the test is complete the specimen and extensometer are removed by simply reversing the above procedure.

*Test Procedure*

Once the specimens are installed in the furnace it has been found that, starting with a furnace from cold, a period of approximately 8 hour is required to attain a test temperature within the range 450–750° C. A further 8 hours is required to reduce temperature gradient effects along the length of the specimens. This latter operation is achieved by the use of the external shunt resistances in parallel with the furnace heating elements. The maximum temperature deviation obtained between twelve specimens, each with a thermocouple attached, has been ± 3° C. with the test temperature controlled to within ± 1° C.

To determine the temperature gradients along one string of specimens at positions between the three normal thermocouples, it was decided to attach twelve thermocouples over one string. These were attached at the positions indicated in Fig. 15. A typical temperature record trace obtained from this experiment at 450° C. showed that the maximum deviation between the twelve thermocouples was ± 2° C.

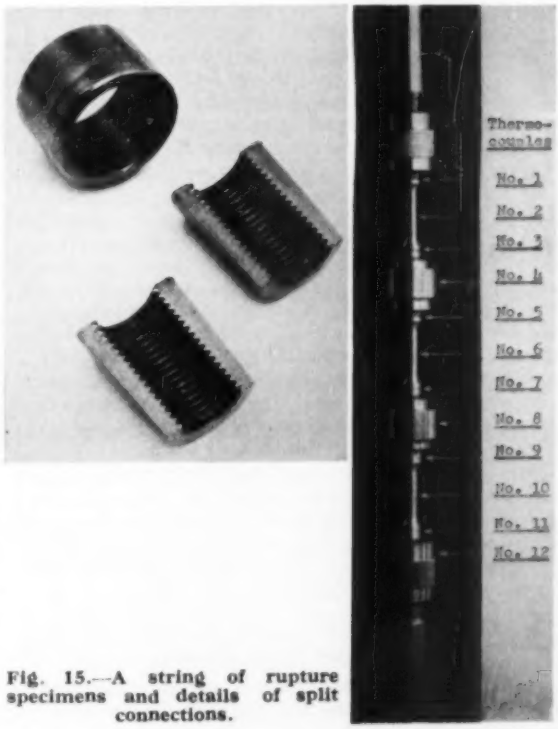
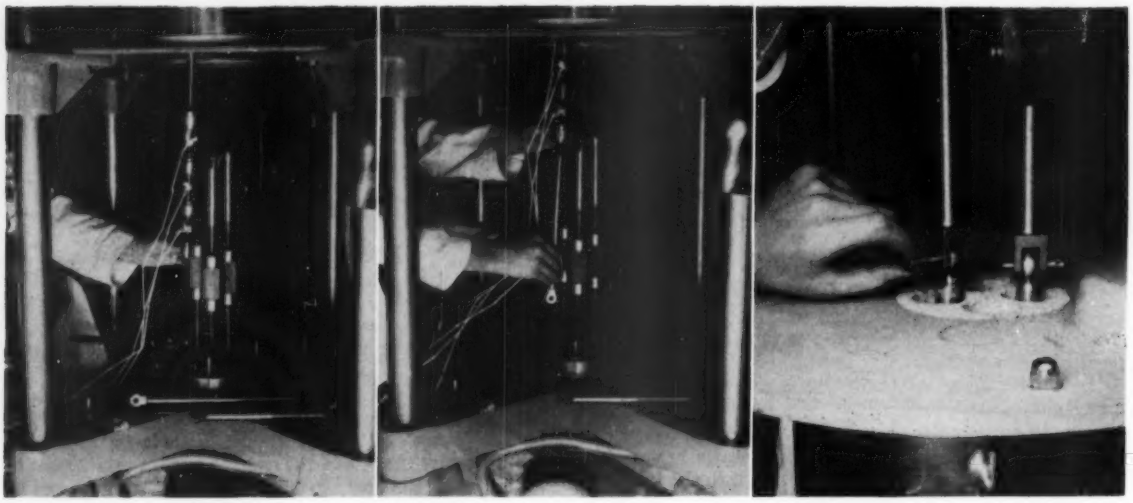



**Fig. 15.—A string of rupture specimens and details of split connections.**



(a) **Stage 1 : string of specimens with top loading bar and thermocouples attached being inserted into the furnace.**

(b) **Stage 2 : bottom loading bar being screwed into position.**

(c) **Stage 3 : string of specimens supported at the bottom and being secured with the top pin.**

**Fig. 16.—Loading specimens into the furnace.**

The effect on the furnace test temperature of the removal of one string for specimen replacement and the reinsertion of this string has been assessed in great detail within the temperature range 500°–700° C. The drop in temperature of the three remaining strings when the fourth was removed and replaced was not more than 10° C. This drop of 10° C. is regained in approximately 1 hour after replacement.

Test specimens having large percentage elongation values before fracture were chosen for the above experiment to establish if any temperature gradient effects would be introduced with large amounts of extension. The specimens each extended between 20 and 30% before fracture occurred, and during the testing of these no temperature gradient effects were recorded.

Application of the load to the specimens to be rupture tested is carried out by the use of the screw jack arrangement. This is positioned under the loading pan (see Fig. 3) and adjusted so that the latter is disconnected from the lever system. The weights which make up the required load are then placed on to the loading pan, and weights and pan are lowered gradually by the jack until the full load is applied to the specimens. This sequence of operations is repeated each time the beam is levelled, and only when the load is very small is the beam re-set without the aid of the screw jack.

For non-interrupted creep tests application of the load is carried out in precisely the same way as described above for rupture testing, except that as each increment of load is applied the dial gauge of the screw jack is read and the reading recorded. This enables a load/extension curve to be constructed.

## Comparison in Performance Between Unisteel Machines and Other Equipment

It was considered advisable to compare the performance of the new machine with the older existing equipment. This comparison has been done by a statistical survey of the temperature control achieved, and by a statistical experiment designed to determine the effect on the rupture life of interruptions to the test. It was not considered necessary to carry out an assessment on the basis of non-interrupted creep testing since, provided the temperature control is adequate and the loading characteristics known, there is no reason to expect differences.

### Temperature Control

Temperature control on the older equipment is achieved by the use of a Prosser type proportional controller. Temperature measurement is by means of Pt/Pt–13% Rh thermocouples and a potentiometer : daily readings are taken. This procedure has been evolved over the past twenty years, during which time the stability of the control equipment has been well established. Temperature recorders are used periodically when required.

In using thermocouples for the measurement of temperature over long time periods the deterioration that occurs in them must be taken into account. To obtain some standard procedure on this the performance of ninety thermocouples of the Pt/Pt–13% Rh type in the

TABLE I.—Pt/Pt-13% Rh THERMOCOUPLES IN TEMPERATURE RANGE 550°–700° C.

| Exposure Time (hr.) | Deviation in Temperature (° C.) | | | Total (%) Within 1° C. |
|---|---|---|---|---|
| | 0–0·5 | 0·5–1·0 | >1·0 | |
| 1,000– 2,000 .. .. | 3 | — | — | 100 |
| 2,000– 3,000 .. .. | 11 | 4 | 1 | 94 |
| 3,000– 4,000 .. .. | 9 | 2 | 1 | 92 |
| 4,000– 5,000 .. .. | 7 | 4 | 1 | 92 |
| 5,000– 6,000 .. .. | 13 | 3 | 5 | 76 |
| 6,000– 7,000 .. .. | 1 | 2 | 5 | 37 |
| 7,000– 8,000 .. .. | 1 | 3 | 7 | 36 |
| 8,000– 9,000 .. .. | — | — | — | — |
| 9,000–10,000 .. .. | 2 | 1 | — | 100 |

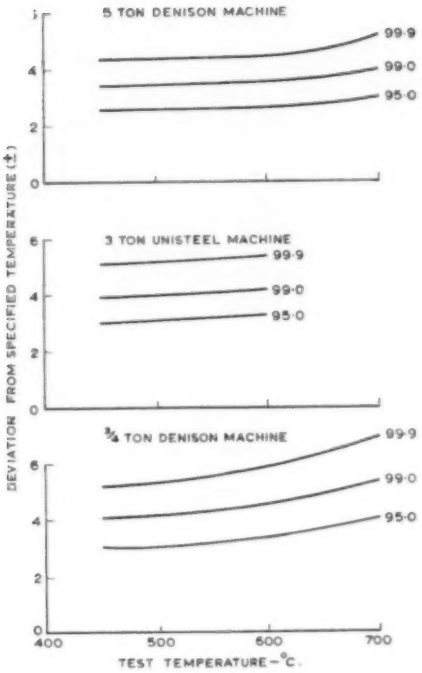



**Fig. 17.—Temperature control of three types of equipment: all furnaces "home-made."**

temperature range 500°–700° C. was recorded. The starting point was either a new thermocouple or a newly-annealed thermocouple. The results obtained have been condensed into Table I, from which will be seen the small amount of deterioration that takes place in times up to 5,000 hours. The three couples out by more than 1° C. in this time were only up to 1·4° C. in error, and they were new couples. In the case of those couples that were annealed prior to service the error did not exceed 1° C. in this time. After 5,000 hours the deterioration progressively increased, although the few couples checked between 9,000 and 10,000 hours gave exceedingly good results. On the basis of this evidence annealing and recalibration after every 5,000 hours was adopted as standard practice.

To compare the temperature control of the different equipments, performance over an extended period has been statistically examined. In this work the Unisteel machine has been compared with the 5 tons and ¾ ton Denison machines, which represent the best and worst control obtained. On both these Denison machines furnaces of our own construction have been used. The data that is given therefore cannot be taken as being relevant to those furnaces supplied by the manufacturer of the machines. Daily readings from the machines were taken, and a total of thirty 5 ton machines and forty ¾ ton machines were considered over a time period of 18 months. With regard to the Unisteel machines, the first production machine installed has been operating for approximately nine months at the time of writing. Consequently, the data available on these machines is not so extensive as that on the other machines. Six machines have been considered, the operating times of which varied from four to nine months.

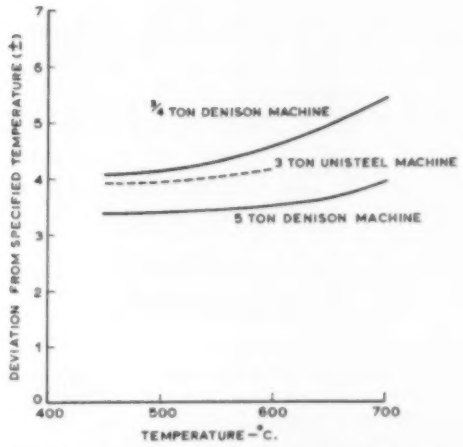



**Fig. 18.—Temperature control of three types of equipment, using 99% confidence limit as the basis of comparison: all furnaces "home-made."**

Classified data were obtained, including details of the temperature variation measured over a range of temperature from 450° to 700° C. The standard deviation and confidence intervals of the temperature distribution were calculated for each temperature and each type of machine. The use of data classified as deviations from the specified temperature without regard to the sign involves several assumptions:—

(*i*) That the mean and specified temperatures coincide.

(*ii*) That the average value of readings within the 1° C. range occurs at the middle of the range.

(*iii*) That the average value of readings greater than 5° C. deviation was 7° C.

In all three cases all these assumptions would give a higher assessment of the error than the true value. This information has been condensed into Fig. 17.

A comparison of the three machines is made on the basis of the 99% confidence limit in Fig. 18. It will be seen that the new machine has a temperature control intermediate between the other two machines considered. This performance is most encouraging, especially when it is realised that it represents the control over the first 4–9 months, which can be taken as the "bedding down" period. As more experience is gained with the equipment improvements to the degree of control might be expected.

### The Effect of Test Interruption

The adoption of multi-specimen rupture testing raises the obvious question of what is the effect on the rupture life of interruption to the test. It should be realised that in single-specimen testing a considerable amount of scatter in rupture life values is obtained under set stress and temperature conditions. To get some facts on this aspect we have done a statistical experiment using the 2¼% Cr-Mo steel with test condition of 10·5 tons/sq. in. at 565° C. (1,050° F). Briefly, we have compared the results obtained in ¾ ton Denison machines with those obtained with our new Unisteel multi-specimen creep machine. In addition, in a further type of machine, the N.P.L. 2 ton, we have inserted one and/or two specimens and have investigated the effect of interruptions to the test. In this latter work a different cast of steel was

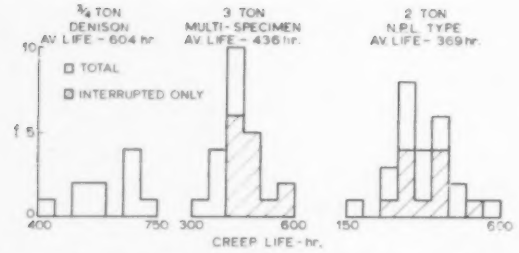



**Fig. 19.—Rupture life of 2¼% Cr-Mo steel at 565° C. under a stress of 10·5 tons/sq. in.**

**Fig. 20.—Rupture ductility of 2¼% Cr-Mo steel at 565° C. under a stress of 10·5 tons/sq. in.**

used from that used for the former work. In the ¾ ton machines, specimen cross-sectional area was $\frac{1}{10}$ sq. in., whilst in the other machines it was $\frac{1}{14}$ sq. in. The results of this work are shown in the form of frequency polygans in Figs. 19 and 20. Fig. 19 deals with the rupture life, whilst Fig. 20 refers to elongation at rupture. The main points that emerged were :—

(*i*) There was a significant difference between the average life from tests in the ¾ ton machine and the average life from tests in the other two machines. The elongation at rupture, however, was similar.

(*ii*) Interruptions to the test have no significant effect on the rupture life, but they do have an effect on the elongation at rupture. Elongation value is reduced due to test interruptions.

(*iii*) The degree of scatter in the rupture life is similar in all three machines.

(*iv*) The two casts of steel tested had similar average lives (i.e. if results from the ¾ ton machines are ignored) but there was a significant difference in ductility.

(*v*) In the Unisteel multi-specimen machine there was an apparent effect due to interruptions of the test, but this is not a real effect. In a machine of this type with strings of three specimens the first specimens to break are obviously the weakest ones, and therefore they have no interruptions to the test. To evaluate the effect of interruptions it is necessary to select a number of specimens and make interruptions occur. This was done in the 2 ton capacity machines.

The reason for the higher average life obtained in the ¾ ton Denison machine has been further investigated. Glen has recently shown that with these smaller furnaces it is possible to obtain considerable differences between the centre and outside of the specimen. This same effect has been confirmed on the machines used in this experiment, and temperature differences of up to 15° C. have been measured between the centre and outside of the specimens. In all cases the centre reading was low. Consequently these tests were done at lower temperatures than realised and have the higher average lives. This temperature gradient has been found to be due to the " cooling effect " of the specimen adaptors, and has been eliminated by rewinding the furnaces to concentrate more heat at the ends and increasing the overall length of the furnace.

In this article the expansion in the creep facilities in the United Steel Cos., Ltd., has been described. Emphasis has been placed on the latest expansion by the introduction of multi-specimen testing techniques. The multi-specimen machine that has been developed, and is now in use, enables both high accuracy creep and stress-to-rupture testing to be done. The machine therefore offers considerable flexibility in operation, which is an extremely important feature in laboratories where a larger number of different steels are being examined at one and the same time. The combination of large batteries of single-point high-accuracy creep machines, single-point stress-to-rupture machines, and multi-specimen creep and/or rupture machines now gives a laboratory that is capable of handling large testing programmes of both the creep and/or rupture type. This combination of a large testing capacity and variability in testing criterion is obviously what is needed in those companies handling a wide range of high temperature steels.


### Acknowledgments

The authors would like to thank Mr. F. H. Saniter, Director of Research of the United Steel Cos., Ltd., for permission to publish this article. They would also like to acknowledge the assistance of their colleagues in the preparation of the article and also in the development of the new machine that is described in it.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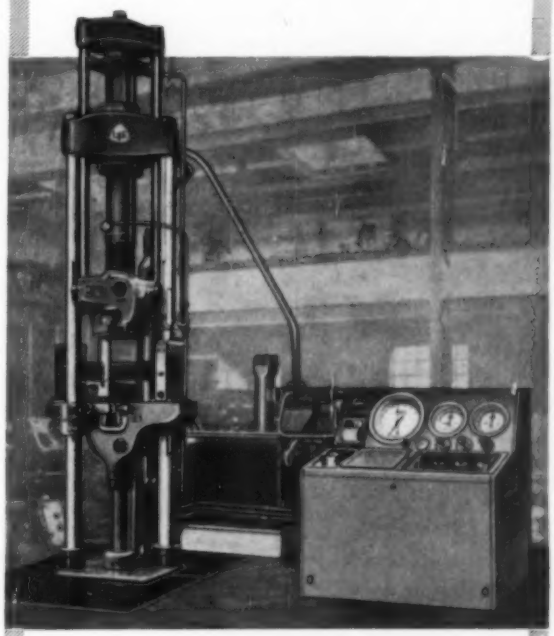

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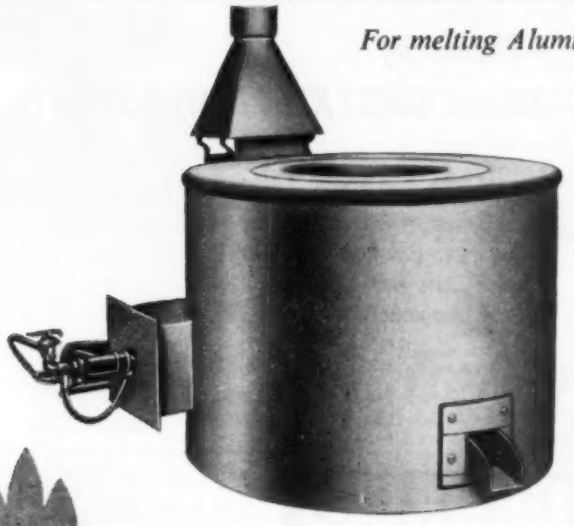

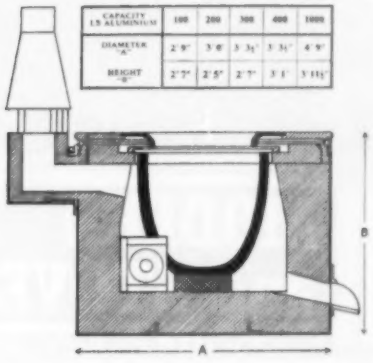


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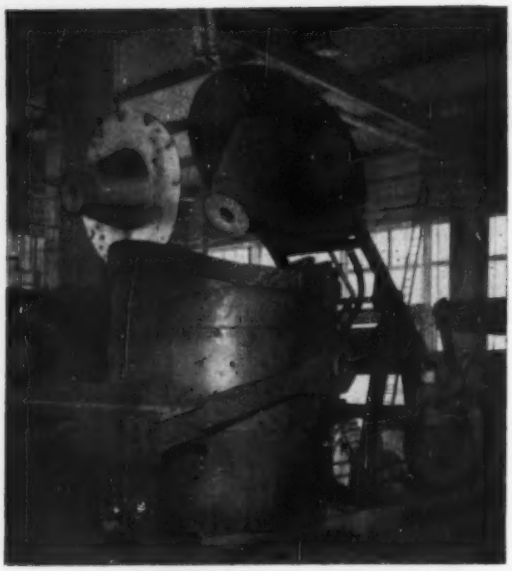

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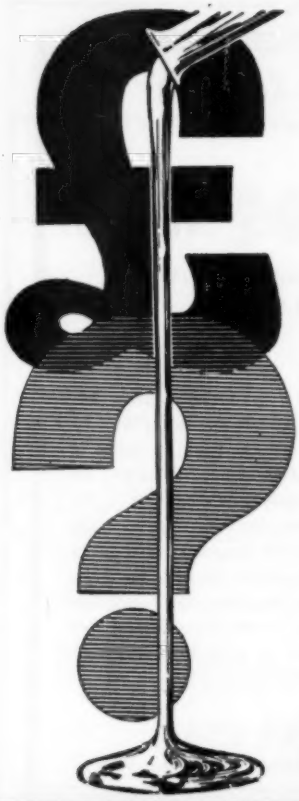

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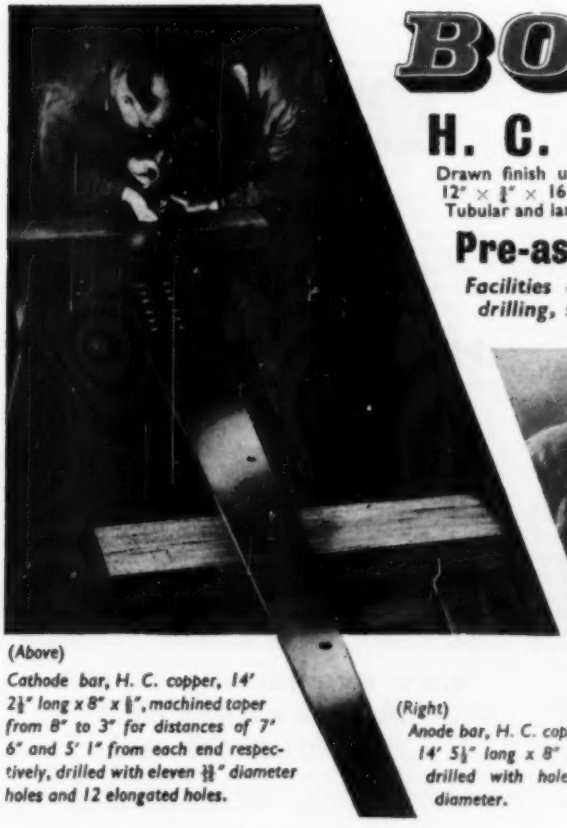

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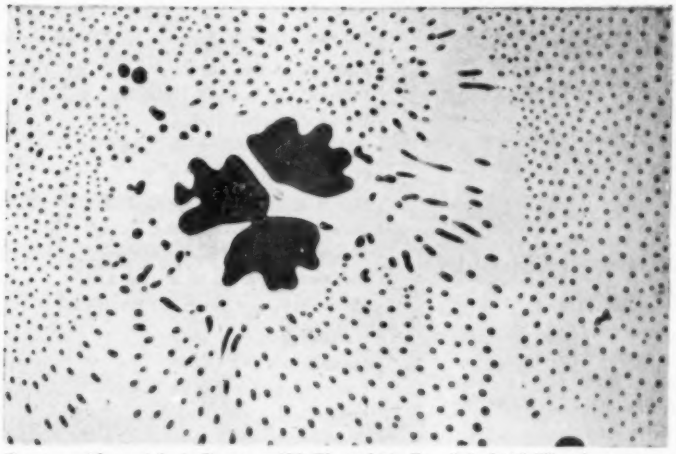

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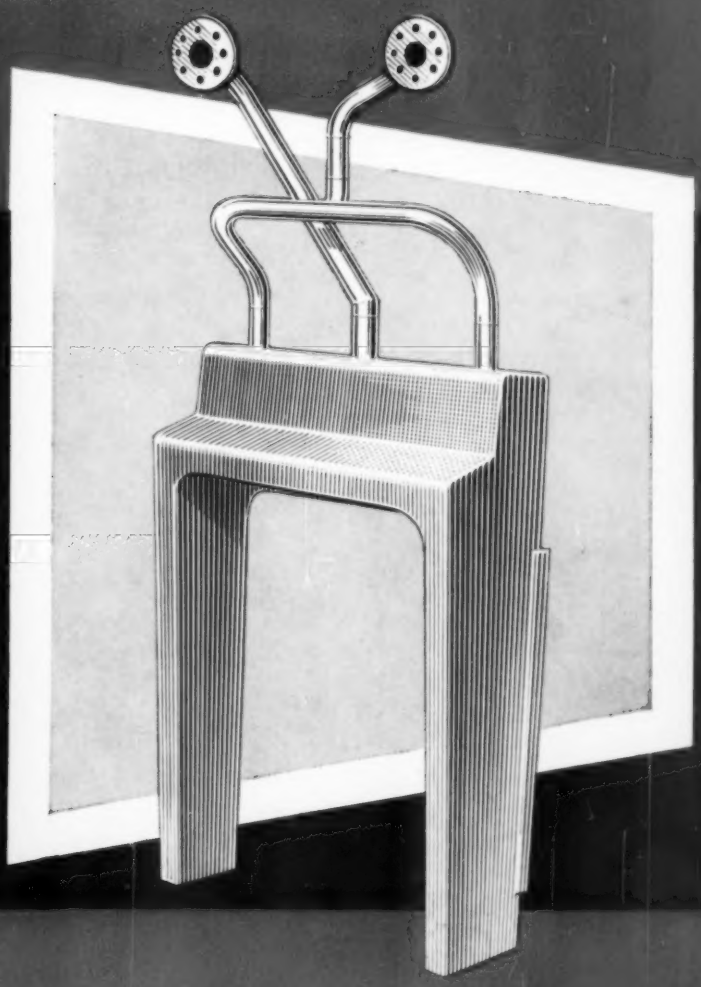

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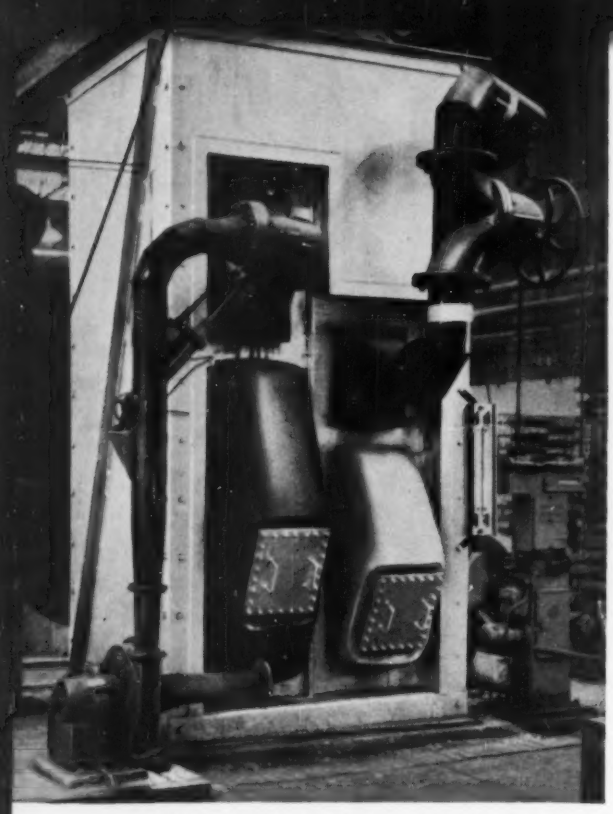

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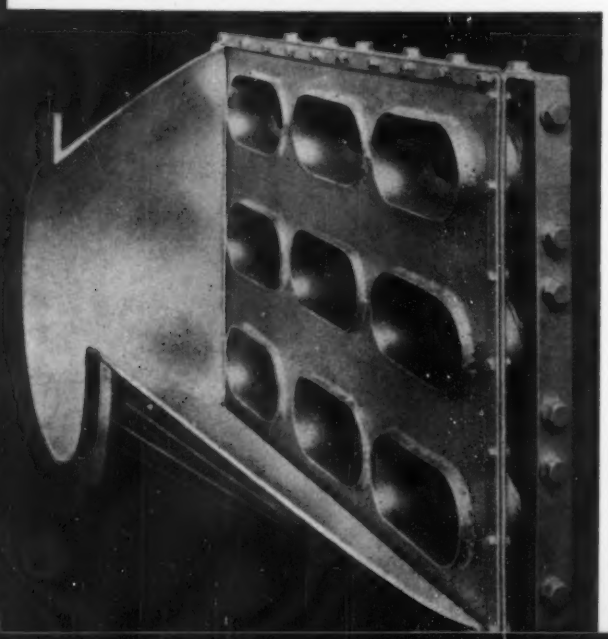

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